

THE RELATIONSHIP BETWEEN DIETARY PROTEIN AND OBESITY IN  
MULTI-ETHNIC CHILDREN

By

Cara Michelle Montgomery  
B.S., University of Kansas, 2007

Submitted to the graduate degree program in Dietetics and Nutrition and the Graduate  
Faculty of the University of Kansas in partial fulfillment of the requirements for the  
degree of Master of Science

---

Debra K. Sullivan, Ph.D., RD

---

Heather J. Leidy, Ph.D

---

Jeannine Goetz, Ph.D., RD

---

Date Thesis Accepted

The Thesis Committee for Cara Montgomery certifies  
that this is the approved Version of the following thesis:

THE RELATIONSHIP BETWEEN DIETARY PROTEIN AND OBESITY IN  
MULTI-ETHNIC CHILDREN

Committee:

\_\_\_\_\_  
Chairperson

\_\_\_\_\_

\_\_\_\_\_

Date Approved:\_\_\_\_\_

## Abstract

The purpose of this study was to determine if a relationship existed between children's protein intake and Body Mass Index (BMI) and/or waist circumference. Multi-ethnic students in grades 3-5 from low socio-economic schools participated in the cross-sectional analysis (n= 1960). Height, weight and waist circumference were obtained and BMI was calculated. Dietary Intake was obtained using a 24-hour recall with child.

BMI percentile was significantly correlated with dietary intake of total protein ( $r = -.062$ ;  $p < 0.01$ ), soy protein ( $r = -.076$ ;  $p < 0.01$ ), total fat ( $r = -.070$ ;  $p < 0.01$ ), and vegetable protein ( $r = -.090$ ;  $p < 0.01$ ). Waist circumference was significantly correlated with total fat ( $r = -.059$ ;  $p < 0.01$ ) and vegetable protein intake ( $r = -.063$ ;  $p < 0.01$ ).

In conclusion, total protein intake was associated with higher BMI and soy and vegetable protein were associated with lower BMI. Increasing non-animal sources of protein may be beneficial in children.

## Acknowledgments

I would like to take the opportunity to thank the many people in my life that made this thesis and my graduation from KU Med possible. First, I would like to thank my parents who have loved and supported me throughout the years. To my mother, who has always been my rock through the hard times and though you never pushed me into the medical field, it inevitably happened and I had the opportunity to follow in an extraordinary woman's footsteps. To my father, who always helped me find humor in the most stressful times, whether it be in a simple phone call or a surprise visit, I appreciated every minute of it. To my best friend Katie, who whenever I was stressed or needed a "time-out" from school, was always up for a Latté land Bliss and conversation. To my thesis advisor, Dr. Sullivan, thank you for the many hours you have spent helping me meet my goals while in Graduate School and for the opportunity to work with you on the KIDS study. It has been a pleasure. To Dr. Leidy, who spent countless hours helping me run my stats and was patient with me every step of the way. To Jeannine, who was the one who inspired me to switch from a Non-Thesis to - Thesis major, I'm glad I took your advice, it really is an accomplishment to be proud of. To anyone I may not have mentioned by name but who is still significant in my life, your friendship and support has meant the world to me throughout the past few years. And to all my fellow classmates, Best of luck in the future, it has been a pleasure getting to know you all.

## TABLE OF CONTENTS

Appendices.....	viii
List of Tables and Figures.....	ix
Chapter	
1. Introduction.....	1
Statement of Purpose.....	3
Research Questions.....	3
2. Review of Literature.....	4
Introduction and Background.....	4
Protein Requirements.....	5
Sources of Protein.....	7
Animal Protein.....	7
Whey Protein.....	9
Plant Protein.....	10
Amino Acids and Physiological Mechanisms.....	11
Short term versus Long term Protein Intake.....	13

Future of High Protein Diets.....	15
3. Methods.....	16
Subjects.....	16
Sample.....	16
Anthropometric Measurements.....	17
Height.....	17
Weight.....	17
Waist Circumference.....	18
Waist-Height Ratio.....	19
Dietary Intake.....	19
Statistics.....	21
4. Results.....	23
Subjects.....	23
BMI Percentile.....	28
Waist Circumference.....	30
Race/Ethnicity.....	32
Best Fit Model.....	37

5. Discussion.....	39
Subjects.....	39
BMI Percentile and Protein Intake.....	41
BMI Percentile and Protein Source.....	43
Waist Circumference and Protein Intake.....	46
Waist Circumference and Protein Source.....	46
Race/Ethnicity and Protein Intake.....	48
Race/Ethnicity and Protein Source.....	49
Race/Ethnicity and Waist Circumference.....	51
Best Predictor.....	52
Limitations.....	52
Future Studies.....	54
Conclusions.....	55
6. Summary.....	56
References Cited.....	61
Appendices.....	72

## APPENDICES

Consent Form.....	72
Data Form.....	80
24 Hour Diet Recall Sheet.....	82



## LIST OF TABLES AND FIGURES

### Tables

Characteristics of Sample.....	24
Diet and Energy Composition Breakdown between BMI Categories.....	25
Protein Intake Compared to BMI Percentile.....	28
Protein Sources Compared to BMI Percentile.....	30
Protein Intake Compared to Waist Circumference.....	31
Protein Source Compared to Waist Circumference.....	32
Race/Ethnicity Compared to Waist Circumference.....	37
Best Fit Model for BMI Percentile.....	37
Best Fit Model for Waist Circumference.....	38

### Figures

Protein Intake by BMI Category.....	26
Protein Adequacy for All Subjects.....	26
Children at Risk for Developing Weight Problems.....	27
Race/Ethnicity by BMI Category.....	28

Total Protein Intake Compared to BMI Percentile.....	29
Protein Sources by BMI Categories.....	30
Total Protein Intake Compared to Waist Circumference.....	31
Protein Intake by Race/ethnicity Group.....	33
Protein Sources by Race/ethnicity Group.....	33
Total Meat Intake by Race/ethnicity Group.....	34
Total Poultry Intake by Race/ethnicity Group.....	35
Total Dairy Intake by Race/ethnicity Group.....	35
Total Soy Intake by Race/ethnicity Group.....	36

# The Relationship between Dietary Protein and Obesity in Multi-ethnic Children

## Chapter 1

### Introduction

Obesity rates in the United States have reached alarming levels with adult obesity prevalence (Body Mass Index, BMI > 30 kg/m<sup>2</sup>) at an all time high of 33% of the population and 66% of adults being overweight (BMI ≥ 25 – 29.9 kg/m<sup>2</sup>). Childhood obesity has nearly tripled in the last two decades with 33% of children now overweight or obese (1). These statistics have prompted many researchers to attempt to find ways to lower the obesity rates in both children and adults. Many fad diets have claimed to be the solution, but as yet, no diet has been found to work for all. A moderate to high increase (25% or above of total energy intake) in dietary protein has been studied throughout the past decade to determine its effectiveness to treat obesity. Investigators have reported several benefits for most individuals who utilize a diet rich in protein (any source) including lowering their body weight and decreasing their body fat percentage (2,3). Researchers have also examined and compared the different sources of protein to determine if one protein source is superior at increasing satiety and lowering body weight. Examples of such comparisons include: lean beef versus lean poultry/fish (4), animal protein versus soy protein (2) and the benefits of whey protein (3).

With the recent popularity of increasing dietary protein in diets, several research studies have been conducted in adults and results indicate that participants have successfully lowered their BMI and overall body fat while being on this type of diet (5). Little is known on the long term benefits or risks of maintaining the moderate to high protein diet and more research is needed (5). Additional investigation is also needed to examine the effect of a moderate to high protein diet in children. Most studies to date have compared protein sources to a child's overall energy intake, but rarely have changed the macronutrient distribution. Gunther et al (2007) recently argued that increasing protein in a child's diet would increase their risk of developing weight problems later in life. The authors concluded that increasing protein intake would also increase energy intake and thus result in weight gain. Gunther and colleagues also examined different sources of protein that children were consuming and found that some sources (vegetable protein and lean animal protein) did not increase children's risk for obesity later in life. This study suggested that more research needs to be conducted on the specific type of protein that children and adolescents are eating, such as lean versus non-lean animal protein and low fat versus high fat dairy sources and balancing that with a lower intake of carbohydrates and fats (6).

The current study will further assess the dietary protein intake of elementary aged children to investigate whether a relationship exists between BMI percentile and waist circumference in this population.

### Statement of Purpose

The purpose of this study is to determine if a relationship exists between weight status (as assessed through BMI percentile), waist circumference, and the amount and type of protein consumed in school – aged children.

### Research Questions

1. Is there a relationship between total protein intake and the children's BMI and/or waist circumference? Then, more specifically, is there a relationship between the source of protein and the children's BMI and/or waist circumference?
2. Is there a relationship between race/ethnicity and overall protein intake and source of protein related to their BMI and/or waist circumference?
3. What is the best overall predictor of children's BMI and waist circumference?

## Chapter 2

### Review of Literature

#### Introduction and Background

Obesity trends in the United States have been on the rise for two decades, with 49 of the 50 states now reporting more than 20% of their adult population as either overweight (BMI = 25 – 29.9 kg/m<sup>2</sup>) or obese (BMI ≥ 30.0 kg/m<sup>2</sup>). Data from the Centers for Disease Control (CDC) indicate that in 2006, 66% of U.S. adults and 33% of children were categorized as overweight or obese. It was also reported that 17.0% of children between the ages of 6-11 years were obese. Research has shown childhood obesity tracks into adult obesity as 80% of overweight or obese children will continue that pattern into adulthood (7). This is cause for concern among health professionals due to the many health risks associated with obesity. Health risks include cardiovascular disease, hypertension, hyperlipidemia, type 2 diabetes mellitus, stroke, liver and gallbladder disease, sleep apnea and other respiratory problems, along with several other risks. (7)

Given the high obesity prevalence, health professionals are searching for solutions to a healthier America. The popularity of diet pills, fad diets, and surgeries have been increasing throughout the last decade. It has been reported that over 40 billion dollars is spent each year on dieting and diet related products (8). While these diets and procedures will work for some, they will not work for most. This raises the question: What can be done to help prevent and treat obesity?

Throughout the past decade, there has been an increasing interest in moderate to high (25% or above of total energy intake) protein diets. Much research has been done to determine the benefits that this diet may have for weight loss and the overall health for adults and children. Suggested benefits of a moderate to high-protein diet include increasing satiety leading to less caloric intake (9); helping to maintain optimal health and treat chronic diseases (10, 11); and to increase bone health (12).

### Protein Requirements

The Estimated Average Requirement (EAR) for protein for children ages 4-8 years of age is 0.76 g/kg/day and the Recommended Dietary Allowance (RDA) is 0.95 g/kg/day or 19 g/day. For children ages 9–14 years of age, the EAR is 0.76 g/kg/day and the RDA is 0.95 g/kg or 34 g/day. An alternative way to define protein requirements is to define the percent of energy that comes from a nutrient. The Acceptable Macronutrient Distribution Range (AMDR) for children ages 4-8 years of age is 10-30% of energy from protein. For older children and adults, the AMDR for protein is 10-35% of total energy.

Protein helps build lean-body mass, which if depleted could cause respiratory failure, decreased immune function and increased morbidity and mortality (14, 15). There has been a recent shift in thinking and instead of taking a nutrient-based approach to better health; nutritionists are taking more of a food-based approach to defining appropriate servings for specific diets. The hope is that by assigning more of a food-based diet, individuals will less likely be protein deficient and in turn will not

be at risk for the negative side effects that could stem from it. There is also an emphasis on obtaining a variety of protein in one's diet. Although different sources of protein supply different types of amino acids and enhance different mechanisms, there has been a recent push to achieve a balanced diet from all sources of protein, both from animal and soy products, along with plenty of vegetable protein (16).

The general belief in most developed countries has been that dietary protein intake is not a nutrient of concern. However, certain populations may indeed fail to consume adequate protein. A study done in Newark, New Jersey on children in 3<sup>rd</sup>-6<sup>th</sup> grade revealed that 69% of the children did not meet the recommended requirements for protein, falling short of the 10-35% recommended protein intake. Of those 69%, most were either African-American or Hispanic (17). Another study conducted in Ontario, Canada comparing higher socio-economic school districts with lower-socioeconomic school districts generated similar results. Students in the lower-socioeconomic district were served less lean meat, higher fat food products and fewer fruits and vegetables (18).

Contradicting the study mentioned previously, Huynh and colleagues (18) researching protein intake in children in Vietnam, found that only 2% of participants were meeting the recommendations for protein while 98% were exceeding recommended levels. For those that exceeded the recommended amounts, protein intake exceeded 50% of their total energy intake. Consequently, the high protein



intake resulted in total fat intake being greater than the 25–35% of total energy intake that is recommended in children (19).

### Sources of Protein

#### Animal Protein

The average daily intake for animal protein has increased over the last two decades, starting at only 24g/day in 1990, increasing to 51g/day in 2000 (10), and increasing again to an average of 56g/day in 2004 (13). Animal protein can be separated into two different categories for research purposes: meat protein (meat, poultry/fish and eggs) and dairy protein. The first category includes but is not limited to: beef, pork, poultry, ham, sausage and fish and eggs. The second category, dairy protein, consists of but is not limited to: cow's milk, custard, yogurt, buttermilk and cheese (6). The DONALD study (Dortmunch Nutritional and Anthropometric Longitudinally Designed Study), done by Gunther et al (2007), followed a cohort of infants into young adulthood. As part of the study, the investigators examined the sources of protein and their impact on participant's BMI at age seven years. There was a positive association between meat and dairy protein intake at age 12 months and BMI at age 7 years. The study did not discuss the types of meat (high fat versus lean) that participants consumed throughout the duration of the study. Key time periods identified in this study were the transition periods at ages 12 months and 5 years. The weaning period where an infant changes from breast milk or formula to milk and other dairy and animal products could cause a significant increase in fat and energy intake resulting in the adverse association with the higher BMI later in life.

The second transition period observed at age 5 years is due to an adiposity rebound that occurs between ages 5 and 6 years. A positive association between total protein and animal protein was found at both transition periods (12 months and 5 years) (6).

Animal protein intake has also been negatively associated with breast cancer in women who reached menarche and their peak in growth earlier than their peers. The Harvard Longitudinal Studies of Child Health and Development (20) followed a cohort of females from infancy into adulthood. Using these data, Berkey and colleagues reported that girls consuming more animal protein and less vegetable protein at ages 3-5 years had earlier age of menarche and earlier age at peak height growth velocity. Similar findings were observed in girls at age 6-8 years. These studies suggest that animal protein intake in childhood may have long lasting implications (20).

Other than beef and poultry, seafood can also be an excellent source of protein. Seafood intake in America is significantly lower than consumption in other countries and currently Americans get less than half of their recommended daily intake of seafood (2-3 servings a week), if any at all. Yaktine and colleagues (2008) conducted a study comparing dietary intake and different sources of protein, and found that beef, poultry and meat alternatives are consumed 60% more over seafood in the American diet. The most common seafood eaten in America by all age groups is tuna, shrimp and salmon (21).

## Whey

The term whey refers to the serum or liquid part of milk that remains after the coagulation of casein into curd during the manufacture of cheese. The whey that remains is usually high in lactose and minerals (22). Whey protein has been used as a supplement to fortify already blended food to help improve the nutritional value. The most fortified foods tend to be from corn soy or wheat soy blend products that require additional protein supplementation. Whey can also be added to milk products. The main argument for added whey protein to food/drinks is to enhance the protein quality of the food (23). By enhancing the quality of protein, the amount of total protein that is needed can be reduced and therefore the amount of money spent on foods/beverages one would otherwise have to buy to meet the daily recommended intake of protein can be decreased (24). Whey protein can also be added to whole-protein milk and other drinks to increase the total protein intake to help with weight gain and overall nutritional status.

Animal data have suggested that whey protein may have a role in obesity prevention (25, 26). Fretedt and colleagues conducted a randomized, controlled trial in adults using a whey supplement. Results indicated that participants taking the whey supplement lost more body fat at 12 weeks than the isocaloric placebo group (27). Whey is believed to play a role in body weight regulation by impacting satiety and thereby reducing food intake (28). There have been few studies conducted on adding whey protein to children's diets to evaluate the benefits (11). Additional research is

needed to determine if whey has an impact on body weight or body composition in children.

### Plant Protein

Plant protein sources include wheat, rice, legumes, soy and nuts. The cereal proteins (wheat, rice oats and corn) make up almost 65% of the world's supply of protein (29). Often plant proteins are referred to as incomplete proteins since they do not have a complete complement of indispensable amino acids.

Soy protein intake has increased over the last decade in the United States. Good sources of soy protein include: soya milk, soy beans, tofu, tempeh, and isolated soy protein that is added to foods (30). Soy protein has also been used as a substitute for both animal meat and dairy products. There are several benefits reported from consuming soy products. Benefits include lowering serum cholesterol levels, lowering total fat intake and saturated fat intake in adults and children. Soy protein is often recommended to be incorporated into low fat diets to help lower lipid levels. Weghuber et al (2008) presented in the American Heart Association Science advisory that a very large intake (more than half the individual's daily protein intake) of soy protein could lower LDL-C levels. Soy protein has also been found to be a possible antioxidant (31).

The impact of soy protein on body weight is still unknown. Several rodent studies have indicated that soy protein diets result in lower body weight and body fat (32, 33, 34). There are limited data in humans. The few studies identified have all

been with adults and have been short term studies with generally small sample sizes. Yamashita and colleagues reported greater weight loss with a soy-based meal replacement versus the control diet (35), whereas Delbert et al reported similar weight loss in the soy versus milk-based meal replacement (36) and Bosello et al found similar weight loss with soy and lean meat in an energy restricted diet (37). No studies were identified evaluating soy protein and body weight in children.

#### Amino Acids and Physiological Mechanisms

Over the past decade there has been an increase in interest in moderate to high protein diets (25% or higher energy from protein) and the benefits they could have on an individual's life (24). These diets have been shown to increase satiety and bone health while decreasing both heart disease and type 2 diabetes mellitus risk factors. Moderate to high protein intake has been shown to increase satiety, reduce energy consumption and help the individual lose weight. A second benefit of a moderate to high protein diet is an increase in thermogenesis within the body which can also increase satiety and augments energy expenditure. The third benefit of a moderate to high protein diet is that it may help with the maintenance and accretion of fat-free mass and improve the retention of lean muscle mass while improving metabolic profiles.

A study conducted by Westerterp-Plantenga and colleagues (2008) in adults compared a high -protein diet (protein/carbohydrate/fat: 30/60/10% energy) to a high-fat diet (protein/carbohydrate/fat: 10/30/60% energy). After 16 weeks, individuals on the high-protein diet reported greater satiety than those on the high-fat diet.

Researchers also found that animal protein resulted in 2% higher energy expenditure than plant-based (soy) protein (38).

Moderate to high protein diets have been linked to reducing risk factors for heart disease. An increase in protein intake (25% or above) appears to have a positive effect on reducing serum triacylglycerol (TAG) levels, increasing HDL cholesterol, increasing LDL particle size, and reducing blood pressure. In a six month clinical study done by Layman et al (2008), women in a higher protein diet had a greater reduction in body weight in TAG and decreased their LDL levels (10).

#### Short Term versus Long Term Protein Intake

High-protein diets (> 35% of total energy from protein) are being debated with what is more practical, safe and beneficial: the short term or the long term diet. Successful results have been seen in short term studies, but there has been a lack of long term studies on the benefits or potential dangers of a high-protein diet. Short term benefits have included an increase in satiety, decrease fat mass and percentage of body weight. The concern is how long these benefits continue to be seen in the individual on the high-protein diet and are there any risks for keeping individuals on that intense of a diet (39, 40).

Most of the research that has been conducted long term only examines high protein-low carbohydrate diets in subjects. There is a lack of long term moderate to high protein diets with moderate carbohydrate diet studies that have been reported.

Discussed below are results from studies that placed subjects on high protein-low carbohydrate diets.

The Nurse's Health Study (NHS) examined long term dietary intake and the development of coronary heart disease in women aged 30-55 years. The study followed 82,802 healthy women for 20 years. The NHS found that on average BMI increased by 2.5 units from baseline, a trend that was seen even when women consumed overall less carbohydrate than their peers who consumed higher amounts of carbohydrate during that time period. A second study, Women's Lifestyle and Health cohort study from Sweden, followed over 42,000 healthy women for 12 years. This study found that women consuming a high-protein/low carbohydrate diet had an increase of 11% in mortality, with an increase by 37% in cardiovascular mortality (39).

There have been studies published since 2003 that show significant weight loss in subjects that have been on high protein-low carbohydrate diets during the first six months of the diet and then weight loss plateaus after one year. After one year on the diet, there was no difference between the high protein-low carbohydrate diet and those that were consuming a low-fat diet. Researchers do not have conclusive evidence that a high protein-low carbohydrate diet will be successful for all those following the diet (41).

Another area of concern with long term high-protein-low carbohydrate diet has been the possibility of developing renal disease. It has been questioned whether

or not the type of protein consumed may play a role in the development of this disease. Currently, there has been no conclusive evidence pointing to the long term use of a high protein diet directly causing the development of renal disease. It has been suggested as a possibility, but it is pointed out that more extensive research will need to be done to prove this theory (42). Regardless, individuals with renal disease should avoid high-protein intake diets because it may accelerate renal damage (41).

#### Future of High-Protein Diets

There are several potential positive effects that a high-protein diet (> 35% of total energy intake) has on an individual's health. Short term effects include improving CHD risk factors such as cholesterol and lipid levels and also helping to increase satiety, which in turn could help lower body weight and fat in overweight or obese individuals. Other short term benefits include improving glucose levels in individuals with type 2 diabetes. The long term effects of high-protein diets on both children and adults needs further research. Increasing protein intake to moderate to high levels (25% or above) could potentially be a key in the fight against obesity epidemic in America.



## Chapter 3

### Methods

A cross-sectional study was conducted using subjects who participated in a larger randomized, controlled intervention study, the Kansas Intervention with Dairy in Schools (KIDS). Subjects were in grades 3-5, from twenty-seven schools that were recruited for the KIDS study. Of these schools, twenty-three were in the Kansas City, Kansas (KCK) school district and four were in the Shawnee Mission, Kansas school district (SMSD). Due to the large number of participants, the study was divided into two cohorts. Cohort 1 represented the twelve schools (6 control and 6 intervention) participating in the first year of the study and cohort 2 represented fifteen schools (7 control and 8 intervention) participating in the second year. The KCK schools that were recruited had a nearly even split in enrollment of students that were male (52%) and female (48%). This district also had a diverse racial and ethnic enrollment with 19% White, 45% Black, 32% Hispanic, 3% Asian and 1% Other (which includes American Indian/Alaskan Native, Pacific Islander or biracial). Children participating in the SMSD had the same split in gender enrollment at 52% and 48% for males and females, respectively. This district was not as diverse racially as the KCK district with 78% White, 8% Black, 9% Hispanic, 3% Asian and 2% Other (30).

Sample. Subjects for this study ranged from age 8 to 12 years and were either in 3<sup>rd</sup>, 4<sup>th</sup>, or 5<sup>th</sup> grade at participating schools. Inclusion criteria for participation in the larger KIDS study included the agreement to participate, the written consent of the parent/guardian and the consent to participate by the child. Exclusion criteria for

the KIDS study included children with an allergy to the dairy product used for the intervention, any chronic medical condition that would impact metabolism, or a wish to not participate in the study. All participation forms were approved by the Human Subjects Committee prior to testing. For the purpose of this ancillary research project, inclusion criteria was extended to only those who had available data for height, weight, waist measurements and dietary intake. All data used were entered by graduate students and checked by faculty insuring that the information was as accurate and reliable as possible.

Height and Body Weight. Height measurements were taken on a portable stadiometer (Perspective Enterprises, Portage, MI). Subjects were measured with shoes removed and were asked to stand up straight, keep hands at their sides and to look forward. If a subject's hair was impeding the researcher from making an accurate measurement, the researcher was required to use a ruler and to manually measure the child's height, placing the ruler on the child's head to get an accurate reading. If this occurred, researchers were required to note that there was a difficulty in measuring the subject's height due to hair. All measurements were measured to the nearest 0.10 centimeter, recorded three times and then averaged.

Body weight was measured on a digital scale (Seca Platform Scale, model 707, Seca Corp., Columbia, MD). Subjects were again asked to remove their shoes and to remove any heavy outer clothing (i.e. sweatshirt or coat). If the subject for some reason was not able to take off their sweatshirt or if they had a cast on an arm or

leg or preferred to keep their shoes on, researchers were required to make a note that excess weight was added to the measurement. Subjects were asked to step on the scale three times, were weighed to the nearest 0.10 kilogram and those measurements were then averaged.

Body mass index (BMI) was then calculated using the kids EZ BMI calculator online (EZ BMI Software, 2009). This software uses the child's exact age, height and weight to characterize the subjects' weight status. Underweight was categorized as less than the 5<sup>th</sup> percentile; normal was 5<sup>th</sup> -84.9<sup>th</sup> percentile; overweight was 85<sup>th</sup> - 94.9<sup>th</sup> percentile, obese was 95<sup>th</sup> to 98.9<sup>th</sup> percentile, and severely obese was at the 99<sup>th</sup> percentile or greater.

Waist Circumference. Waist circumference was measured using a measuring tape (Creative Health Products, Inc., Plymouth, MI) according to the methods of Lohman (44). Subjects were asked to step behind a privacy curtain and to lift their shirt up so that the measurement could be made at the small of the waist while looking forward and inhaling and exhaling normally. For subjects who were uncomfortable with raising their shirt, researchers measured over the thinnest layer of clothing that was showing. This usually included a dress, an undershirt or a t-shirt and was noted by the researcher that the measurement was done over clothing. Waist measurements were measured to the nearest 0.10 centimeter and were measured in triplicate and averaged. If the three measures were not within 2 centimeters of each other a fourth measure was taken.

Waist–height ratios were calculated to determine whether individuals were at risk or not for developing weight problems later in life. This measurement was calculated by dividing the subject’s waist circumference (cm) by their height (cm), with individuals considered at risk with a ratio  $\geq 0.5$ . This measurement serves as a preventative tool and is easier to calculate than the child’s BMI percentile (45).

Dietary Intake. Subjects participating in the study were interviewed by trained research staff to obtain a multiple-pass 24 hour recall during baseline testing. Recalls were conducted on weekdays (Tuesday through Friday) and not after holiday or missed school days to achieve the most normal representation of usual dietary intake on school days. To ensure that the subject could give the most accurate recall possible, 2- and 3-dimensional visual aids were provided for the subject to use to describe size and amounts of food and/or beverages that were consumed the previous day. The recalls were then entered into the Nutrition Data System for Research (version 2006 and 2008, University of Minnesota, Minneapolis, MN) to determine energy and nutrient content.

To ensure quality control and minimize recall and computing errors, all researchers were required to complete a training session with the lead investigator. Researchers were also required to complete ten 24-hour recall entries into NDSR and their recalls were evaluated by the lead investigator. An error rate less than 6% was required to pass training and to be certified to obtain diet recalls on subjects.

From the 24 hour recall collected, information about the subject's protein intake was obtained to be used for data analysis. Along with the subject's total protein intake, animal and vegetable protein consumption and sources of protein were computed. Protein intake was converted from servings in NDSR to gram amounts. There are a total of eight protein sources that were included in the analysis. These include: meat, lean meat, poultry/fish, lean poultry/fish, dairy, reduced fat/fat free dairy, egg, and soy. Those protein sources included in the meat group are: beef, veal, lamb, pork, cured pork, game, cold cuts/sausage, organ meats and the leaner meat group included the leaner portions of this similar group. The poultry/fish group included higher fat/fried sources of poultry/fish and the leaner group included poultry/fish that were lower in fat. The dairy group included whole milk, ready-to-drink whole milk, full fat cheese, full fat yogurt, and full fat yogurt that had been artificially sweetened. The reduced fat dairy group included all dairy that was reduced in fat. The egg group consisted of real eggs and egg substitute, while the soy group consisted of legumes, nuts and seeds and meat alternatives (46, 47).

Statistics. Descriptive statistics such as frequencies, means, and standard deviations were calculated to characterize the population and included age, gender, BMI, waist circumference, energy intake and race/ethnicity.

The dependent variables for this analysis were BMI and waist circumference. The independent variables included total grams of protein intake, the different sources of protein and subject's race/ethnicity. Protein adequacy was calculated for subjects

overall and then characterized by BMI category. For subjects consuming less than 10% of their total energy intake from protein, protein intake was considered inadequate. Subjects consuming between 10-35% of their daily total energy intake from protein were considered adequate and those over 35% of their total energy intake from protein were characterized as consuming over the recommended amount.

For research question one, a Pearson's correlation test was used to determine the relationship between the subject's protein intake and BMI percentile and between the source of protein and subject's BMI percentile, respectively. For research question two, a Pearson's correlation was used to determine the relationship between subject's protein intake and waist circumference and between the source of protein and subject's waist circumference, respectively. For research question three, a Pearson's correlation was used to determine a relationship between race/ethnicity and subject's protein intake. After all tests were run, a one-way ANOVA was used to determine whether any significance existed between groups for BMI percentile and race/ethnicity and BMI percentile and the different BMI groups. An ANOVA was also used to find significance between protein sources and race/ethnicity.

To determine the best predictor for subject's BMI percentile and waist circumference, a stepwise linear regression was used, which included variables that were found to be significant in the correlation tests (48).

## Chapter 4

### Results

The overall purpose of this study was to determine whether a relationship existed between protein intake and the child's BMI percentile and waist circumference. Relationships were evaluated by comparing the subject's overall protein intake with their diet and the different sources of protein consumed. The second purpose was to determine if race/ethnicity influenced the outcome of BMI percentile or waist measurements when compared to the subject's protein intake. Results are reported in the tables and figures in this section.

#### Subjects

The sample for this study included 1960 subjects from the 27 schools participating in the KIDS study. All subjects included in the analysis had completed both the physical measurements and the 24-diet recall at baseline. Table 1 depicts the characteristics of the sample.

Table 1. Characteristics of Sample

<b>Subject Characteristics</b>	<b>Mean <math>\pm</math> SD</b>
Sample Size	1960
Age (years)	9.14 $\pm$ 1
Gender (Number of subjects/percent)	
Male	923 (47.1%)
Female	1037 (52.9%)
BMI	20.66 $\pm$ 24.18
BMI Percentile	71.38 $\pm$ 27.91
BMI Group (Num. of subjects/percentile)	
Underweight	39 (2 %)
Healthy weight	1034 (54.8%)
Overweight (85-94.9 Percentile)	340 (17.3%)
Obese (95 <sup>th</sup> -99 <sup>th</sup> Percentile)	416 (21.2%)
Severely Obese (>99 <sup>th</sup> Percentile)	131 (6.7%)
Waist Average (cm)	65.14 $\pm$ 10.86
Total kcal (g)	1715.45 $\pm$ 742.7
Energy Intake Breakdown (g/day)	
Protein	64.32 $\pm$ 29.24 (15.33% $\pm$ 3.75)
Male	67.35 $\pm$ 2.28
Female	61.79 $\pm$ 11.79
CHO	269.57 $\pm$ 153.87 (55.66% $\pm$ 8.91)
Fat	58.24 $\pm$ 32.25 (29.62% $\pm$ 7.27)
Race/Ethnicity (Num. of subjects/percent)	
White, non-Hispanic	451 (23%)
White, Hispanic	716 (36.5%)
Black, non- Hispanic	539 (17.5%)
Other	254 (13%)

From these general descriptive statistics, subjects were separated into respective BMI categories: underweight, healthy weight, overweight, obese and severely obese. A more detailed analysis was then conducted on total energy intake and diet breakdown. Table 2 shows the results of this analysis.

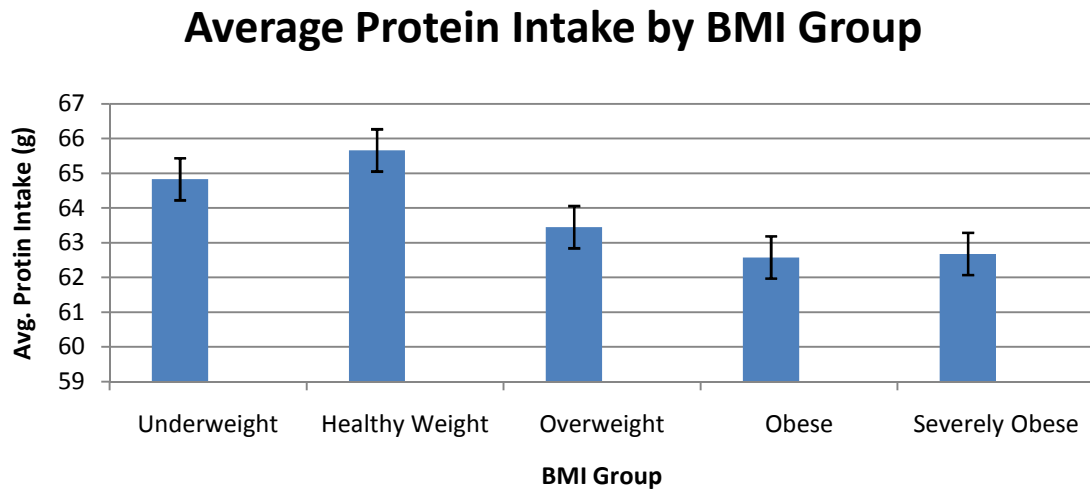


Table 2. Diet and Energy Composition Breakdown between BMI Categories

	All	Underweight	Healthy Weight	Overweight	Obese	Severely Obese
Energy (kcal)	1715.4 ± 742.7	1845.2 ± 350.0	1765.0 ± 33.2	1682.1 ± 97.0	1643.5 ± 328.6	1587.6 ± 80.5
Protein (g)	64.3 ± 29.2	64.8 ± 7.2	65.6 ± 11.4	63.4 ± 38.4	62.6 ± 15.8	62.7 ± 5.02
CHO (g)	269.6 ± 53.9	254.1 ± 59.8	247.0 ± 8.9	233.3 ± 15.9	229.1 ± 38.3	217.9 ± 25.7
Fat (g)	58.2 ± 32.2	62.8 ± 11.3	60.0 ± 11.6	57.5 ± 5.9	55.6 ± 12.0	53.9 ± 18.6
Protein %	15.3 ± 3.7	13.9 ± 5.5	15.1 ± 2.9	15.5 ± 3.6	15.6 ± 3.7	16.2 ± 0.67
CHO %	55.7 ± 8.9	54.6 ± 31.5	55.9 ± 23.9	55.1 ± 8.1	55.9 ± 0.03	54.8 ± 8.8
Fat %	29.7 ± 7.3	29.7 ± 5.3	29.6 ± 10.2	30.1 ± 3.9	29.3 ± 5.03	29.9 ± 8.2

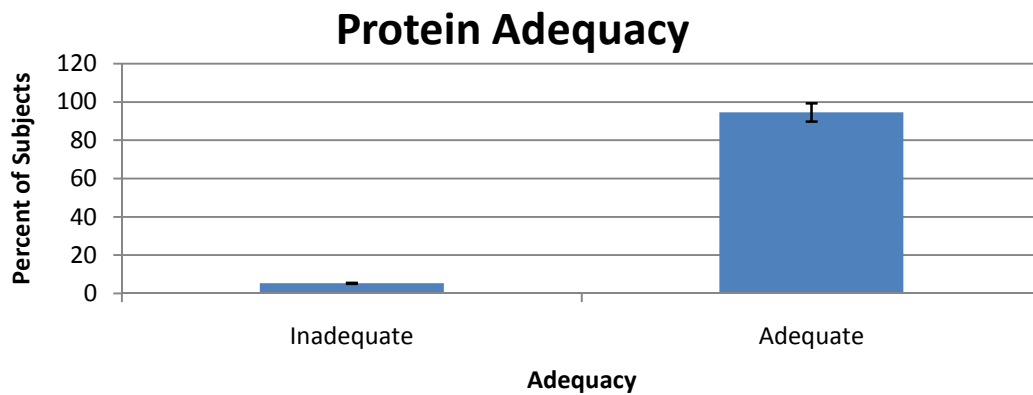
The average protein intake for all subjects was  $64.32 \pm 29.24$  g/day. Protein intake was slightly higher in the healthy weight ( $65.63 \pm 11.38$  g/day) and underweight category ( $64.8 \pm 7.2$  g/day) than the overweight category ( $63.45 \pm 38.42$ ) and the obese and severely obese categories ( $62.58 \pm 15.83$  and  $62.68 \pm 5.02$ , respectively). However, there was no difference found between protein intake and BMI categories.

Figure 1. Protein Intake by BMI Category



Protein adequacy was then determined for all subjects. Adequate protein intake was defined as 10-35% energy as protein while inadequate protein intake was defined as  $\leq 10\%$  energy as protein. Over consumption of protein was defined as  $\geq 35\%$  energy from protein. There were no subjects categorized within the over consumption category.

Figure 2. Protein Adequacy for All Subjects



The subject's waist circumference-to-height ratio is a good indicator for cardiovascular risk (31). Figure 3 depicts the population at risk.

Figure 3. Children at Risk for Developing Weight Problems

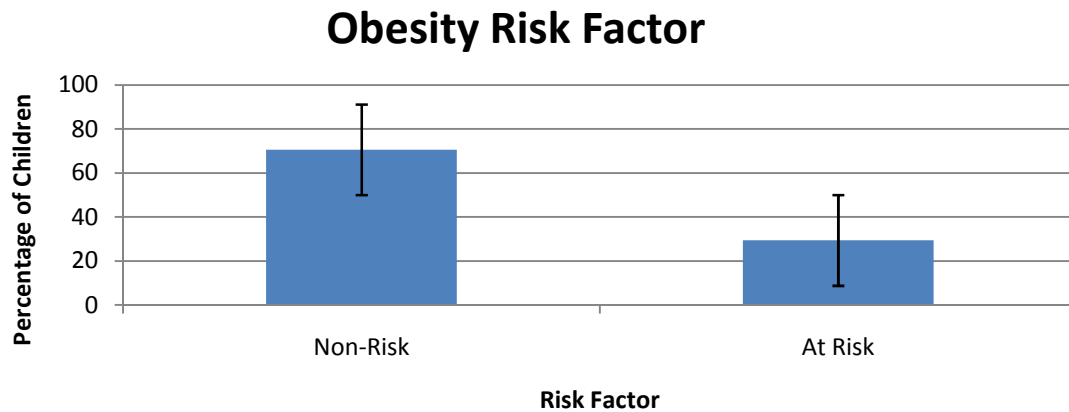
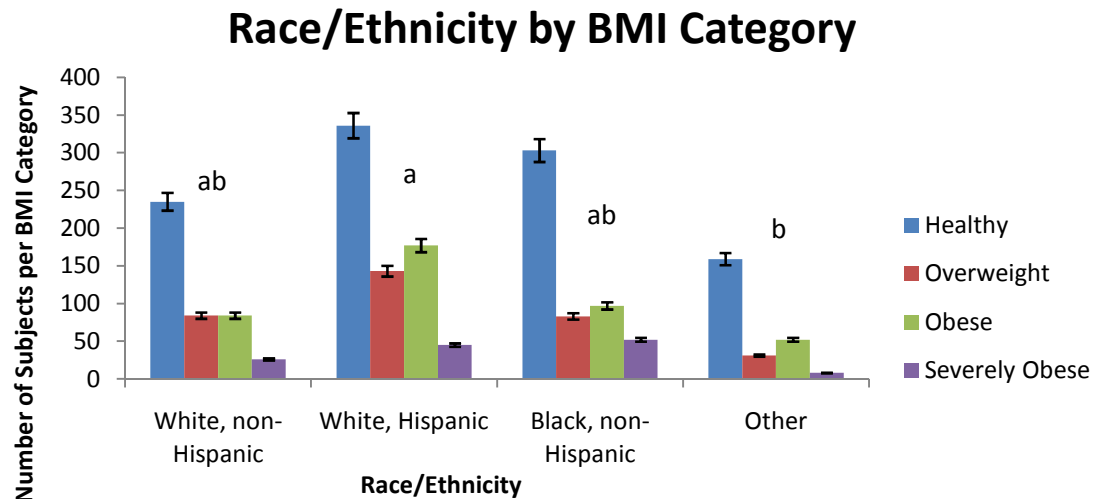


Figure 4 provides a breakdown of the BMI categories healthy weight, overweight, obese and severely obese by race/ethnicity category. A trend was observed in white - Hispanics and Other between race/ethnicity categories ( $p = .074$ ). There was no significance within each group.

Figure 4. Race/Ethnicity by BMI Category



Difference between letters denotes significant;  $p < 0.05$  level

**BMI Percentile Correlations:** The primary research question was to determine if there was a relationship between protein intake and BMI percentile. Table 3 depicts the correlation between protein intake and subject's BMI percentile. Significance was found in subject's total protein intake ( $p = .006$ ), total fat intake ( $p = .002$ ) and vegetable protein intake ( $p = .000$ ).

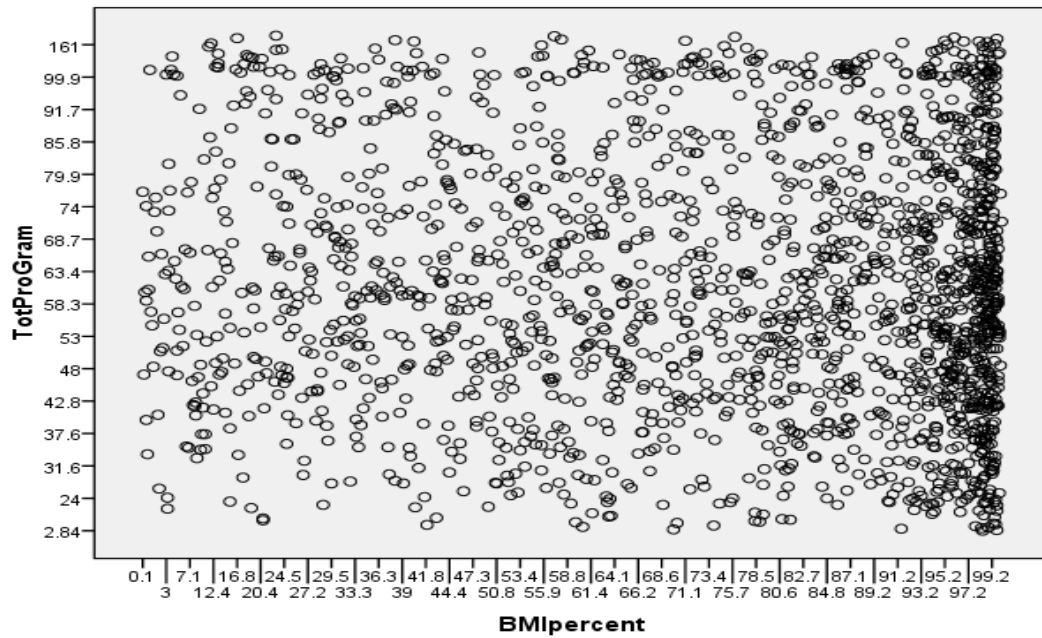
Table 3. Protein Intake Compared to BMI Percentile

	Pearson Correlation	p value
Percent Protein Intake	.041	.068
Total Protein Intake (g)	-.062**	.006
Total Fat Intake (g)	-.070**	.002
Animal protein (g)	-.039	.081
Vegetable protein (g)	-.090**	.000

\*\*Correlation is significant at the 0.01 level (2-tailed)

Figure 5 is a scatter plot that shows the relationship between subject's BMI percentile and total protein intake. The correlation was negative with significance found at  $p = .006$ .

Figure 5. Total Protein Intake Compared to BMI Percentile



Results for the correlations between protein types and BMI are listed in Table 4. The only significant relationship observed was soy protein and BMI percentile.

Table 4. Protein Sources compared to BMI Percentile

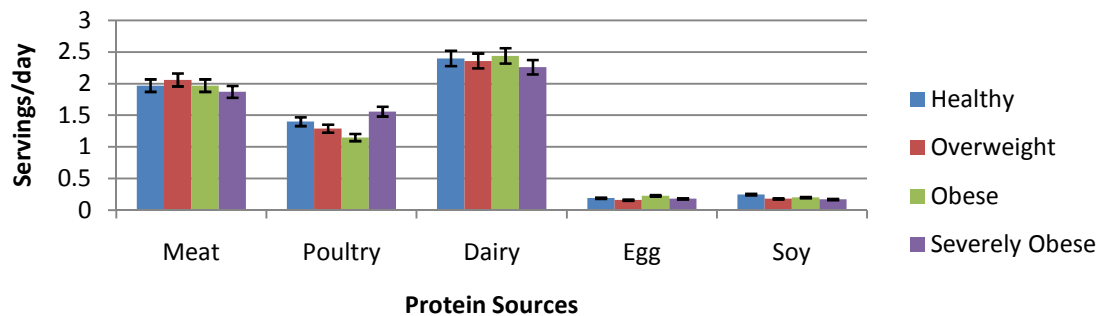
	Pearson's Correlation	p value
Protein Source		
Meat	.006	.791
Poultry	-.041	.071
Dairy	-.031	.172
Egg	-.005	.841
Soy	-.076**	.001
Lean Protein Source		
Meat	.011	.639
Poultry	-.011	.630
Dairy	.001	.950

\*\*Correlation is significant at the 0.01 level.

Figure 6 depicts the dietary protein sources for the different weight categories.

There was no significance between protein sources and BMI percentile.

Figure 6. Protein Sources by BMI Categories



Waist Circumference: The correlations between total protein intake and waist circumference and the different protein sources and waist circumference are listed in tables 5 and 6. In table 5, significance was found in percent protein intake ( $p = .025$ ), total fat intake ( $p = .009$ ), and vegetable protein ( $p = .005$ ).

Table 5. Protein Intake Compared to Waist Circumference

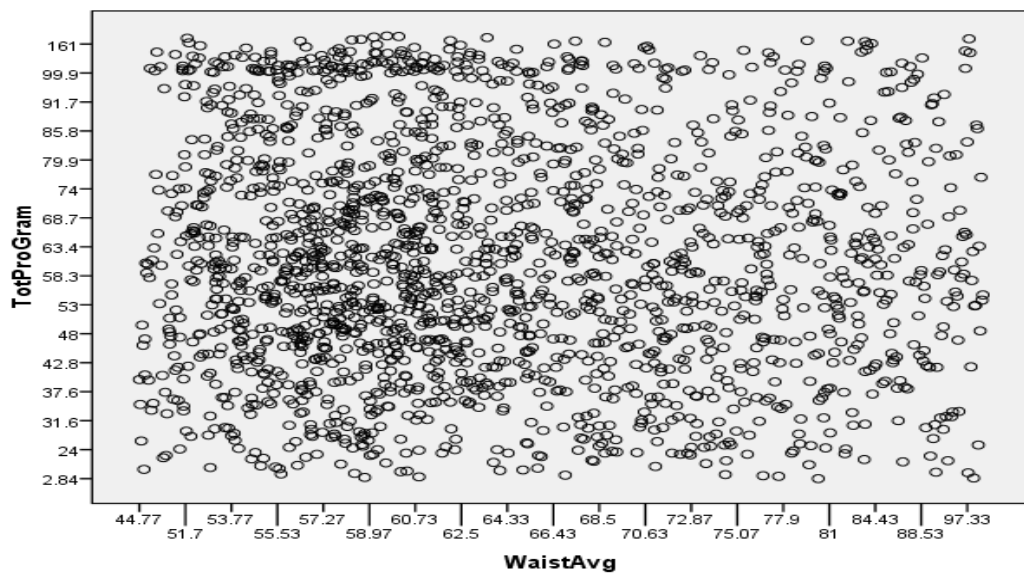
	Pearson's Correlation	p value
Percent Protein Intake	.051*	.025
Total Protein Intake (g)	-.044	.054
Total Fat Intake (g)	-.059**	.009
Animal Protein (g)	-.027	.226
Vegetable Protein (g)	-.063**	.005

\*\*Correlation is significant at the 0.01 level

\*Correlation is significant at the 0.05 level

Figure 7 is a scatter plot that shows the relationship between waist circumference and total protein intake.

Figure 7. Total Protein Intake Compared to Waist Circumference



As seen in Table 6, no significance was found between protein sources and waist circumference.

Table 6. Protein source Compared to Waist Circumference

	Pearson's Correlation	p value
Protein Source		
Meat	.000	.994
Poultry	-.027	.239
Dairy	-.024	.295
Egg	.004	.863
Soy	-.030	.181
Lean Protein Source		
Meat	-.006	.782
Poultry	-.001	.960
Dairy	.013	.577

Race/Ethnicity: Protein intake was analyzed for each race/ethnicity group. A significance was found for total protein intake in white–Hispanics ( $p = .000$ ) and black non-Hispanics ( $p = .000$ ). The correlation between protein intake and white–Hispanics was negative, while a positive correlation existed for black non–Hispanics. There was also significance between white–Hispanics and white, non-Hispanics ( $p = .004$ ), white–Hispanics and black non–Hispanics ( $p = .000$ ) and white–Hispanics and the Other race/ethnicity ( $p = .021$ )



Figure 8. Protein Intake by Race/Ethnicity Group

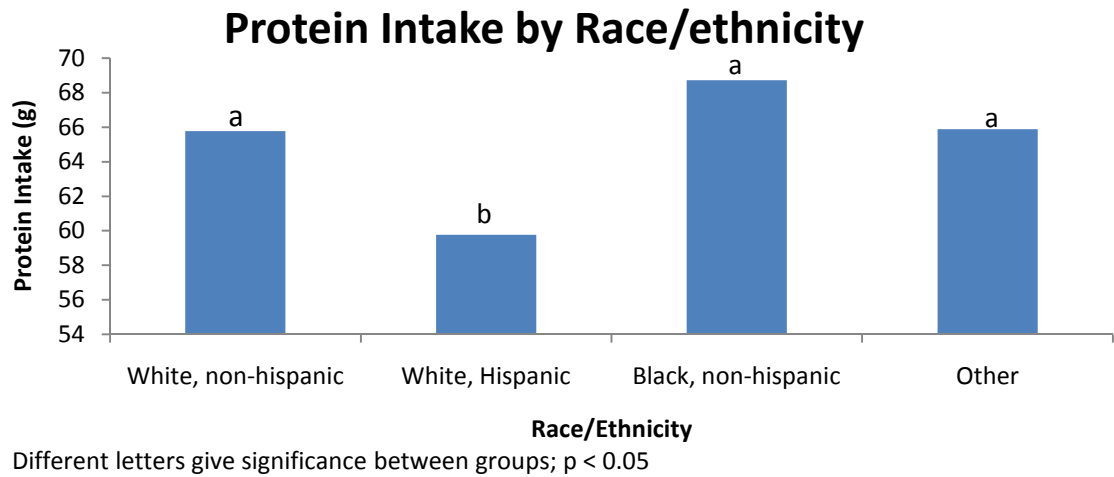
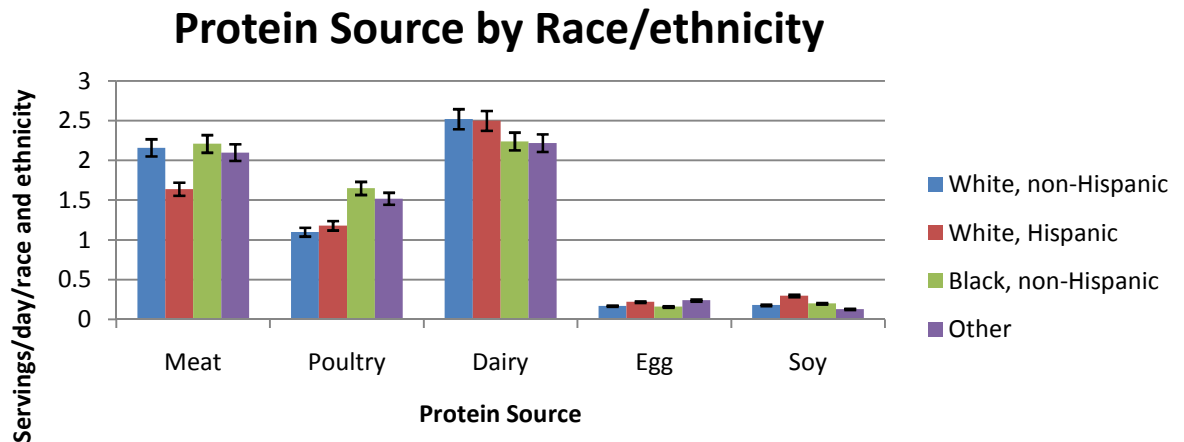


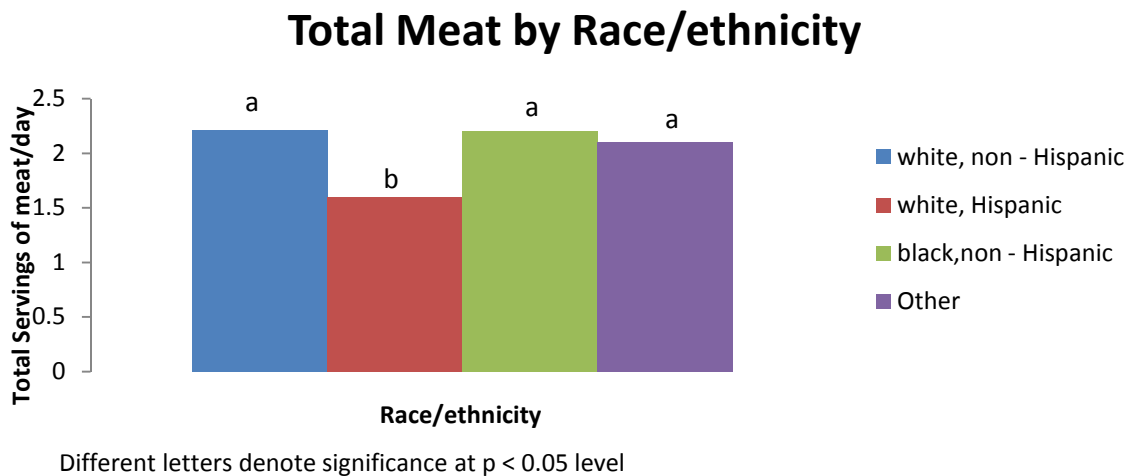
Figure 9 shows a breakdown of protein source servings for each race/ethnicity group. Significance was found between groups and is seen in Figures 10, 11, 12, and 13. There was no difference between groups for egg.

Figure 9. Protein Servings by Race/ethnicity Group



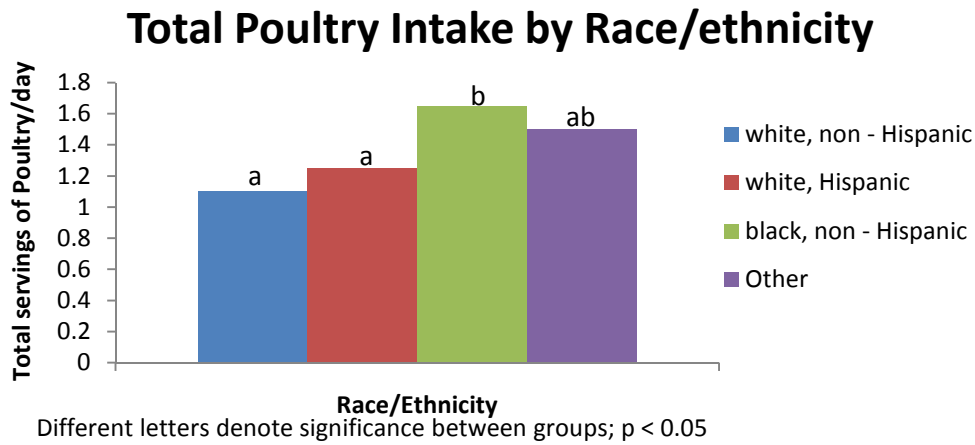
For servings of total meat, significance was found between white–Hispanics and white, non–Hispanics ( $p = .000$ ), white–Hispanics and black non–Hispanics ( $p = .000$ ) and white–Hispanics and the other race/ethnicity ( $p = .007$ ). Figure 10 depicts these results.

Figure 10. Total Meat Intake by Race/ethnicity Group



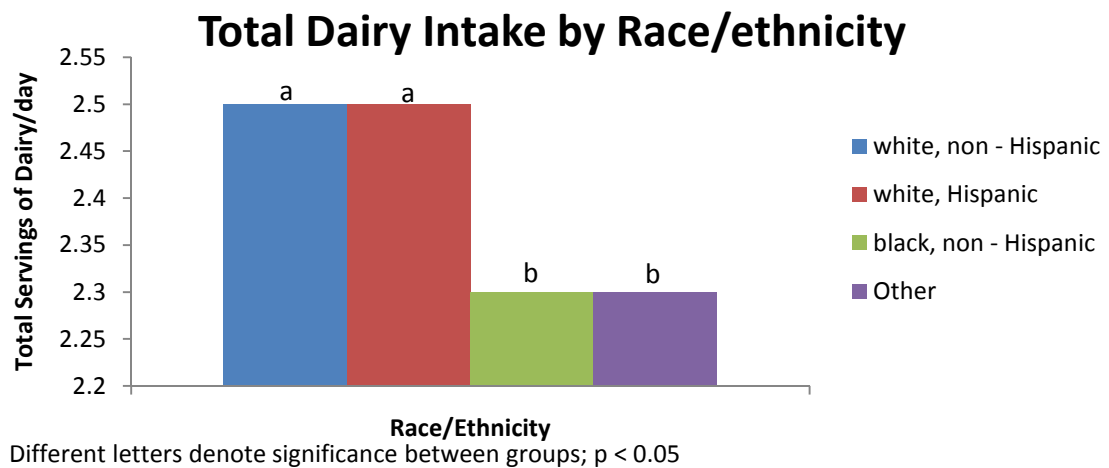
For total poultry intake, there was significance between white, non–Hispanics and black, non–Hispanics ( $p = .001$ ) and between white–Hispanics and black non–Hispanics ( $p = .002$ ). Figure 11 below depicts these results.

Figure 11. Total Poultry Intake by Race/ethnicity



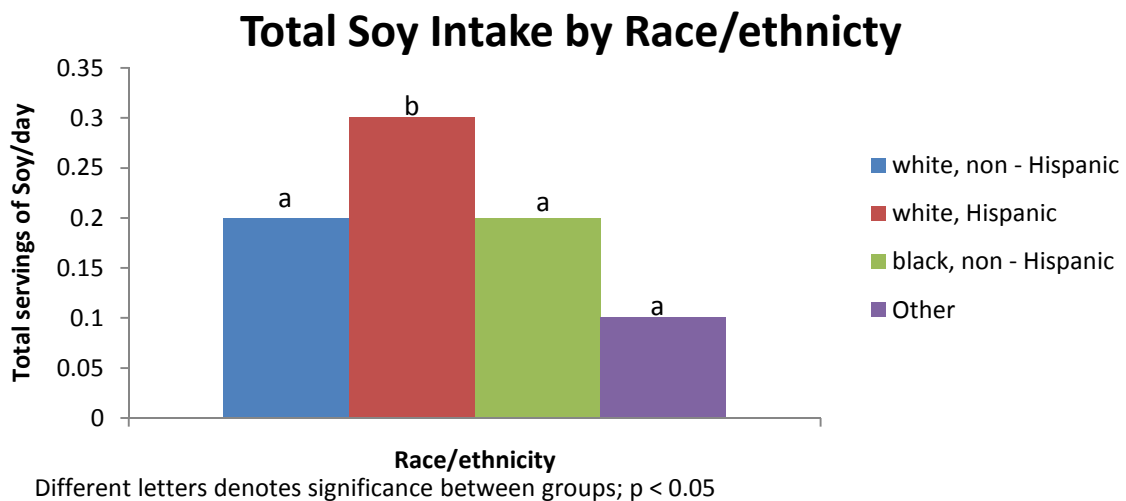
For dairy as a protein source, there was significance between white, non-Hispanics and black, non-Hispanics ( $p = .008$ ), white-Hispanics and black, non-Hispanics ( $p = .006$ ), white, non-Hispanics and Other ( $p = .034$ ) and white-Hispanics and Other ( $p = .036$ ). Figure 12 depicts these results.

Figure 12. Total Dairy Intake by Race/ethnicity Group



For soy as a protein source, there was significance found between white, non-Hispanics and white-Hispanics ( $p = .003$ ) and white-Hispanics and black, non-Hispanics ( $p = .011$ ) and white-Hispanics and Other ( $p = .000$ ). Figure 13 below depicts these results.

Figure 13. Total Soy Intake by Race/ethnicity Group



Waist measurements were also compared to subject's race/ethnicity. Pearson's correlations were run and the results are reported in Table 7. Significance was found in white, Hispanics ( $p = .000$ ) and the Other category ( $p = .001$ ).

Table 7. Race/ethnicity Compared to Waist Circumference

	Pearson's Correlation	p value
Race/Ethnicity	-.063**	.005
White, non-Hispanic	-.035	.119
White, Hispanic	.119**	.000
Black, non-Hispanic	-.037	.101
Other	-.077**	.001

\*\*Correlation is significant at the 0.01 level (2-tailed)

Stepwise multiple regression was used to determine the best predictor for subject's BMI percentile. Factors that were included in the model were those found to be significant in the Pearson's correlations. These factors include protein intake, fat intake, gender, and race/ethnicity ( $R^2 = .026$ ) (Table 8). With the subjects used, lower total vegetable protein intake ( $\beta = -.067$ ;  $p = .007$ ), being male ( $\beta = .081$ ,  $p = .000$ ), falling into the Other category for race/ethnicity ( $\beta = -.062$ ;  $p = .008$ ), being white- Hispanic ( $\beta = .057$ ,  $p = .017$ ) and having a lower soy intake ( $\beta = -.056$ ;  $p = .022$ ) were predictive of a higher BMI percentile.

Table 8. Best Fit Model for BMI Percentile

	b	SEb	$\beta$	p
Constant	72.893	1.679		
Vegetable Pro.	-.190	0.71	-.067	.007
Male	4.538	1.258	.081	.000
Other	-5.180	1.943	-.062	.008
White, Hispanic	3.305	1.385	.057	.017
Soy Protein	-2.763	1.202	-.056	.022

Stepwise Multiple Regression;  $R^2 = .026$

Stepwise multiple regression was also used to determine the best predictor for subject's waist circumference. Factors that were included in the model were those found to be significant in the Pearson's correlations with waist circumference. These factors include fat intake, protein intake, vegetable protein intake, race and gender ( $R^2 = .023$ ) (Table 9). Being white-Hispanic ( $\beta = .116$ ;  $p = .000$ ), being male ( $\beta = .082$ ;  $p = .000$ ) and having a lower vegetable protein intake ( $\beta = -.054$ ;  $p = .017$ ) were predictive of a higher waist circumference.

Table 9. Best Fit Model for Waist Circumference

	b	SEb	$\beta$	p
Constant	64.47	.618		
White, Hispanic	2.605	.509	.116	.000
Male	1.795	.488	.082	.000
Vegetable Protein	-.060	.025	-.054	.017

Stepwise Multiple Regression;  $R^2 = .023$

## Chapter 5

### Discussion

The purpose of this project was to determine whether a relationship exists between protein intake, BMI percentile and waist circumference in school-aged children. Secondary purposes included examining the relationship between specific protein sources and race/ethnicity in comparison to their BMI and waist circumference. The relationships found between protein intake/protein sources, BMI percentile, and waist circumference measurements are discussed below.

#### Subjects

In this study 17.3% of children were found to be in the overweight category (between 85<sup>th</sup> and 95<sup>th</sup> percentile), 21.2% were found to be in the obese (between 95<sup>th</sup> and 99<sup>th</sup> percentile) and 6.7% were found to be in the severely obese category (above the 99<sup>th</sup> percentile). National data reported by Ogden and colleagues from the most current NHANES study indicate that 33.3% of US children this age are overweight (at or above the 85<sup>th</sup> BMI percentile) and within those, 17% were obese (between the 95<sup>th</sup> and 97<sup>th</sup> BMI percentile). The children in the current study have lower rates of overweight (17%) (between 85<sup>th</sup> and 95<sup>th</sup> BMI percentile), but higher rates of obesity (21.2%) than the national data. Those that were in the severely obese category were lower than the national average (6.7% versus 11.4; respectively) It is noted by the author that Ogden defined obese as individuals between the 95<sup>th</sup> and 97<sup>th</sup> BMI percentile, when in this study, obese individuals were defined between the 95<sup>th</sup> and 99<sup>th</sup> BMI percentile. These statistics are more than three times the target set by

Healthy People 2010, and currently show no sign of reversal (32). It was predicted that subjects in this study would follow national BMI trends, given that the cohort was racially diverse and representative of all in the United States.

The average energy intake for the subjects was 1715 kcal/day. Subjects in the underweight category consumed an average 80 kcal/day more than those in the healthy weight category. As the BMI percentile increased for subjects, their overall kcal/day intake decreased as follows: healthy weight = 1765 kcal, overweight = 1682 kcal, obese = 1643 kcal and severely obese at 1587 kcal. These calorie levels were not statistically different, but other investigators have reported significantly greater underreporting as BMI increased in children and teens (49, 50)

Greater underreporting in overweight and obese individuals has been attributed to one of two factors. One is that obese individuals may actually consume fewer calories but are far less active than their peers who have a lower BMI (33). A second factor could be that obese individuals may underreport their actual food intakes by leaving out snacks and second servings at meals (51). Information on physical activity was not available for the current study and thus we were unable to explore any influence of activity.

We did not find any significant difference in reported protein intake and BMI category. Lindroos and colleagues also reported no association between weight status and protein reporting accuracy (52). In adults, it has been reported that there is greater underreporting of energy as compared to protein intake which implies that



carbohydrate, fat and alcohol may be more underreported than protein intake (53). These factors would play a significant role in subjects BMI category outcome, making it harder to determine which macronutrient is the driving force behind subjects BMI category.

#### BMI Percentile and Protein Intake

A negative correlation was found for protein intake and BMI percentile ( $p < 0.01$ ) providing some supporting evidence that the greater the protein intake, the lower the subject's BMI percentile. Though the correlation was weak, it is supported by other studies. Eisenstein and colleagues cited support for a high protein diet in children for weight-loss, stating that those on a high protein diet will lose more weight than those who are on a lower protein diet (33). Although subjects in this cohort were not placed specifically on a higher protein diet, it was predicted that those who consumed more protein daily than their peers would have a lower BMI percentile.

Van Vaught and colleagues followed 364 children, age 8-10 for six years investigating the relationship between protein intake and children's body composition, fat mass and fat-free mass. Results confirmed that there was an inverse relationship between protein intake in children and fat mass in children specifically in females ( $\beta = -1.12 \pm 0.56$ ;  $p = 0.03$ ,  $\beta = -1.13 \pm 0.51$ ;  $p = 0.03$ , respectively). It was suggested by Eisenstein's study that high protein intake ( $> 35\%$  total energy intake) may decrease body fat gain and increase fat free mass gain in female children (54). Females have generally been found at this age group to meet the daily

recommendations for protein but have lower amounts than the male gender. Instead, they get their energy intake from other sources such as fruits and vegetables (55).

Several studies (56, 57) conclude male gender is positively associated with dietary protein intake. Females tend to consume more fruits and vegetables in their diet over protein. In the current study, males were found to have a higher average protein intake than females (67.35 g/day versus 61.79 g/day, respectively). Other macronutrients or sources of food were not evaluated in this study, but based on the differences in protein intake found, it is predicted that females are getting their energy from other food sources. Of those food sources, fruits and vegetables are a possible source to evaluate further to determine if that relationship holds true for this cohort.

The majority (94%) of subjects were consuming protein within the recommended range and only 6% fell below the recommended lower limit of 10% daily energy intake from protein sources. No one was consuming more than was recommended. These findings are similar to those reported by Storey et al, examining diets of adolescents and comparing it to their BMI. Storey and colleagues reported that adolescents consuming more protein in their diet than their peers had lower BMI's. In addition, they reported that most adolescents do get the recommended amount of macronutrients in their diets and rarely fall below those guidelines. The authors suggested that researchers need to take a closer look at the source of adolescent's diets, as meals consumed at fast food restaurants and away from home may be possibly increasing the amount of fat in the diet (58). Sources of

food are becoming increasingly significant and adolescents may need to begin choosing leaner sources of protein and decreasing overall fat intake to improve diets (59).

### BMI Percentile and Protein Sources

Another part of the first research question examined the relationship between protein sources and subject's BMI percentile. A negative correlation was found between soy protein intake and subject's BMI percentile. This was the only statistically significant finding for protein source. While this was a weak correlation, it is supported by other studies. Konig et al reported that adults in a 34 week trial that replaced two meals a day with soy protein beverages had lower BMI's at end study than control participants. This study suggested that even a protein substitute such as soy can significantly lower BMI in individuals. This could be beneficial for schools to utilize and for researchers to investigate further in children. Elementary schools could begin to introduce soy to children at a younger age and it could be used as a meat substitute for schools, helping to increase their protein intake (56). It remains unclear where the soy protein is coming from in subject's diet and given the knowledge that soy intakes were low in this study, it is necessary to investigate further to determine the exact relationship that soy protein has with subjects in this study.

The current study did not find any significance in any other source of protein. This is contradictory to what other studies have found about meat, poultry, dairy and egg consumption and lowering of BMI. A study done by Farnsworth and colleagues

studied the effects of two weight loss diets differing in protein to carbohydrate ratio, the high protein diet (27% protein, 44% carbohydrate, 29% fat) versus the standard protein diet (16% protein, 57% carbohydrate, 27% fat) but only used meat, poultry and dairy as protein sources. There was a 12 week energy restriction phase (6-6.3 MJ/d) and a 4 week energy balance (approximately 8.2 MJ/d) phase. Farnsworth et al, found that weight loss and total fat loss did not differ between groups ( $7.9 \pm -0.5$  kg;  $6.9 \pm -0.4$  kg, respectively) at end study. The researchers reported that women's total lean mass was significantly preserved ( $p = 0.02$ ) with the high protein diet ( $-0.1 \pm -0.3$  kg) over the standard protein diet ( $-1.5 \pm -0.3$  kg). Meat, poultry and dairy were all found to be beneficial sources of protein to help subjects with their health (60). The differences observed between the current study and others may be due to different population age (i.e., children versus adults) and/or the limitation of only using one day of dietary intake on the children.

Egg was not a significant source of protein for the current study. However, there are other studies that have found that egg protein is beneficial for lowering body weight and fat mass. Vander Wal and colleagues conducted a study on 152 men and women, age 25-60 ( $BMI \geq 25$  and  $\leq 50$ ) and randomly assigned them to four groups. The Egg group, the Egg Diet group, the Bagel group and the Bagel Diet group. Those that were in the Egg Diet and Bagel Diet group were instructed consume a 1000 kcal energy deficient, low fat diet in addition to eating their specified breakfast 5 days a week for 8 weeks. Individuals in the Egg and Bagel groups were instructed to not change their diet. After the 8 week study period, individuals in the Egg Diet

group showed a 61% greater reduction in BMI ( $-0.95 \pm 0.82 \text{ kg/m}^2$  versus  $-0.59 \pm 0.85$ ,  $P < 0.05$ ), a 65% greater weight loss ( $-2.63 \pm 2.33 \text{ kg}$  versus  $-1.59 \pm 2.38 \text{ kg}$ ,  $P < 0.05$ ), a 34% greater reduction in waist circumference ( $P < 0.06$ ) and a 16% greater reduction in percent body. There was no difference among those in the Egg and Bagel Diet. This study showed that weight loss can be enhanced on an egg diet along with calorie restriction (61). Again, the differences between the studies could be due to different population ages and study design.

#### Waist Circumference and Protein Intake

Significant negative correlations were found for total fat intake and for vegetable protein intake, indicating that the greater the intake of fat and vegetable protein, the smaller the waist circumference. Although the correlation was weak, it has been shown by others that the increase of vegetables (protein from vegetable sources) can lower BMI and decrease waist circumference. This is shown in the results from a study conducted by Wang et al where they examined vegetable protein and its effect on blood pressure. The secondary results showed that there was a significant decrease in waist circumference over the 18 month intervention for those who consumed the high vegetable protein diet (62).

An increase in fat intake, however, is not consistent with previous study findings which have shown a positive correlation with waist circumference. It was not expected to have a significant negative correlation with waist circumference and was hypothesized to instead have a positive correlation with both BMI percentile and

waist circumference. It is unclear why fat intake was negatively correlated with waist circumference.

#### Waist Circumference and Protein Sources

There was no protein sources found to be significantly correlated with waist circumference. Waist circumference is often a predictor of BMI percentile and given that the correlation between BMI percentile and soy protein (the only significant source) was weak, it may have been difficult for a relationship to be picked up between waist circumference and protein sources.

Dairy was most consumed by subjects, with an average of 2.4 servings/ day but was not found to be a significant source. Zemel and colleagues conducted a study on forty- one adults, dividing them into three groups, low calcium diet (400-500 mg of dietary calcium/d supplemented), high calcium diet (800 mg of dietary calcium/d supplemented) or the high- dairy diet (1200-1300mg of dietary calcium/d supplemented). All subjects were put on a balanced deficit diet (500 k/cal) for 24 weeks and all lost total body fat and weight. Waist circumference measurements had the greatest change from baseline to end study ( $p < 0.01$ ) for all groups. The low calcium diet group lost  $5.3 \pm 2.3\%$ , the high calcium diet group lost  $12.9 \pm 2.2 \%$  and the high calcium diet lost  $14.0 \pm 2.3 \%$  of their body fat in their abdominal region, being reflected in their waist circumference measurements (63). With those results, it would be predicted that individuals with a higher dairy intake would have a lower waist circumference measurement. Reasons this might not be reflective in the current

study is that neither dairy intake nor fat content within the dairy source were controlled for. Dairy recommendations emphasize that individuals consume low fat dairy products. Subjects in this study may have consumed most protein from dairy, but may have been getting the additional fat from whole milks, cheeses, and yogurts, counteracting the benefits in dairy consumption.

### Race/ethnicity and Protein Intake

All relationships between race/ethnicity and protein intake were found to have weak correlations. There was a negative relationship between white-Hispanic and protein intake and there was a positive relationship between black, non-Hispanics. Mazur et al conducted a study on diet and food insufficiency among Hispanic youths in 2003. The researchers reported that Hispanic youths exceed dietary recommendations for saturated fat, cholesterol and sodium. Also Hispanic youth tended to have a lower socio-economic status and protein intake tended to be lower in those households. This is again shown with the negative correlation between white-Hispanics and total protein intake. The study also discussed that parents' diet may play a significant role in a child's diet and that if the parents' protein intake is cut in half, a white, Hispanic child's protein intake would be lower than those of another race/ethnicity ( $67.4 \pm 56.0$  compared to  $76.4 \pm 89.2\text{g}$  ;  $p = 0.066$ ) (59).

There was a positive correlation for BMI percentile for those who were white-Hispanic and for those who were of the Other category. National trends show that white-Hispanics have the overall highest rates for childhood obesity, followed by

Native Americans, non-Hispanic Blacks and non-Hispanic Whites, respectively (64). The significant correlations between these races/ethnicities in this project are supported by these national trends. Native Americans were collapsed along with Asians and those that checked other for race/ethnicity and could play a role in its significance.

#### Race/ethnicity and Protein Sources

As part of the second research question, protein sources were also analyzed by race/ethnicity. All correlations were weak, however there was significance found between race/ethnicity and protein sources.

Total Meat: For servings of total meat, significance was found between white-Hispanics and white, non-Hispanics black, non-Hispanics and the other race/ethnicity ( $p = .007$ ). White-Hispanics were shown to have lower intakes of meat servings per day compared to the Other three categories for race/ethnicity. The National Cancer Institute's findings state that meat isn't usually the primary source of protein for white-Hispanics when compared to other protein sources (56, 48). Black, non-Hispanics typically consume most of their protein intake from meat and poultry. A study conducted in Minneapolis with adolescent African-Americans found that meat/poultry account for the largest portion of their protein intake, with 3-4 servings of meat or poultry consumed each day (65).

Total Poultry: For total protein intake, there was significance between white, non-Hispanics and black, non-Hispanics and white-Hispanics and black, non-



Hispanics. The Minneapolis study looking at meat and poultry intake in adolescents found that most black, non-Hispanics typically consume higher amounts of meat and poultry in their diet over other race/ethnicities (65). This would also support the findings from the National Cancer Institute that white, non-Hispanics get their protein from other sources and not poultry. The same goes for white, Hispanics, who typically get their protein from other sources (56).

Total Dairy: For total dairy intake, there was significance between white, non-Hispanics and black, non-Hispanics and white, non-Hispanics and Other, white-Hispanics and black, non-Hispanics and white, Hispanics and Other. The National Cancer Institute's research found that typically white, non-Hispanics consume more dairy products than other races/ethnicities. Similar results were found for white-Hispanics, although they usually consume higher fat dairy products (whole milk, cheeses, and yogurts) compared to white, non-Hispanics (56, 64). Black, non-Hispanics have been found to typically consume less dairy products (specifically milk) and usually consume more soft drinks or sugar based beverages (65). The Other category was difficult to evaluate because it combined different races/ethnicities.

Total Egg: There was no significance found in this category. Egg sources were not found to be largely consumed within this cohort. A limitation for this category is that dietary intakes were only taken on weekdays (Tuesday- Fridays) and weekends were not included. Subjects may have consumed more egg products than

this study is aware of. It is a limitation for protein sources that multiple days of recall including weekend days were not used to get a more accurate account of subject's average protein intake.

Total Soy: There was significance found when soy was used as a protein source. The significance was found between white, non-Hispanics and white-Hispanics, white-Hispanics and black, non-Hispanics and white-Hispanics and Other. Even though the intake amounts were not large, white-Hispanics were found to consume more protein from soy than from any of the other race/ethnicities.

#### Race/Ethnicity and Waist Circumference

The correlations between race/ethnicity were weak; however, there was a positive significant correlation found between waist circumference in white - Hispanics and a negative correlation found within the Other race/ethnicity group. The study previously discussed by Mazur et al, also reported that white-Hispanics tended to have a greater BMI percentile than the Other races/ethnicities when protein intake was examined. White-Hispanics tend to consume less protein than Other races/ethnicities, thus it would be expected that both their BMI percentile and waist circumferences would be higher (59). It would be expected that the Other race/ethnicity category would follow the same trend; however it instead had a negative waist correlation. This is difficult to determine where the difference between the two took place, given that there are several races/ethnicities combined in the Other category.

### Best Predictor for BMI Percentile and Waist Circumference

Though the relationship was weak, the best predictors for BMI percentile found that a lower total vegetable protein intake ( $\beta = -.067$ ;  $p = .007$ ), being male ( $\beta = .081$ ;  $p = .007$ ), falling into the Other category for race/ethnicity ( $\beta = -.062$ ;  $p = .008$ ), being white, Hispanic ( $\beta = .057$ ;  $p = .017$ ) and having a lower soy intake ( $\beta = -.056$ ;  $p = .022$ ) were predictive of a higher BMI percentile for subjects. These factors have all been found to be significant predictors in numerous studies discussed previously in this manuscript.

The relationship was again weak but the best predictors for waist circumference found that being white – Hispanic ( $\beta = .116$ ;  $p = .000$ ), being male ( $\beta = .082$ ;  $p = .000$ ) and having a lower vegetable protein intake ( $\beta = -.054$ ;  $p = .017$ ) were predictive of a higher waist circumference. Again, these predictors have been found to be significant in other studies and were previously discussed.

### Limitations

This current study has several limitations that must be considered when interpreting the results. Twenty-four hour recalls are considered a reliable tool for measuring dietary intake. However, for this study recalls were not removed for individuals that were considered unreliable for any reason, or for recalls that had been deemed significantly different from a normal day (i.e. such as subject consumed a lot less /a lot more food on that particular day). Unreliable and non- typical days for diet recalls were not removed because the cut points for those red flags were not yet

established for the overall study. Any subject that had a measurement for height, weight, waist circumference and a 24- hour diet recall was included in this analysis.

Only one recall per subject was included in this study. This makes it difficult to truly assess the subject's dietary intake. It would have been beneficial to have multiple recalls for all subjects to have an accurate account of how much and what type of protein subjects are consuming. Given the large number of subjects participating in the study, this may not have been feasible.

Attention needs to be given to the age group used and whether the recalls were truly reliable. Livingstone et al conducted a study discussing the accuracy of portion sizes reported by children. The authors indicated this age group may not be able to accurately remember the exact amount that he/she had the previous day even if prompted by visual aids. When second helpings are consumed, especially with differing portions, it can become confusing for children. Providing food preparation details can be difficult for a child if he/she is not around while food is being prepared. Ingredients are then defaulted to unknown and can make a difference when analyzing the subject's diet (66). This recall is not considered 100% accurate and could influence the analysis (i.e. leaner sources). If food sources were unknown, they would have been defaulted to a previously determined fat amount in the NDSR program. This may explain why total fat was negatively correlated with BMI percentile, instead of being positively correlated, as other studies have reported.

Another issue to be addressed is whether the subject may have either under or over-reported, which may have been possible for this study. Fisher et al suggest that weight status of the subject could influence the subject's diet recall. This would be an inverse influence between weight status and diet recall (67). Taking a closer look at Table 2 in the results section, those who fell into the underweight category had higher total energy intake, total fat intake and total carbohydrate intake than those in the normal weight category. One might suggest that if the child knew that they were underweight, they might over-report their eating habits to closer to approximate normal values. On the other side, those that were severely obese consumed the least amount of energy, had lower total protein, total fat and total carbohydrate intakes. There is a possibility of both under-reporting and over-reporting. Physical activity was not included in the analysis and it may also influence the outcomes of weight status and waist circumference.

### Future Studies

This was a cross-sectional study using data from a larger intervention study. Therefore, in order to gain a better understanding of the influence of a moderate to high protein diet on children and adolescents, the study would need to be directly geared towards analyzing protein intake within that specific age group. There are few studies available that work directly with school aged children, however with childhood obesity and the incidence of type 2 diabetes mellitus on the rise in this age group, further investigation may yield results that could help reverse the obesity trends occurring today.

## Conclusions

In conclusion, total protein intake was negatively correlated with BMI percentile with vegetable protein and soy protein negatively correlated with both BMI percentile and waist circumference. White-Hispanics and those in the Other race/ethnicity category were associated with a higher BMI percentile and waist circumference. Results from this study could suggest that moderately increasing protein intake in children, specifically from vegetable protein or soy protein sources could result in lowering of children's BMI percentile and waist circumference. Further attention should be given to the white-Hispanic race/ethnicity in searching for ways to lower their overall BMI percentile. These suggestions could potentially lead to a decrease in the prevalence of childhood obesity.

## Chapter 6

### Summary

The purpose of the research project is to determine whether a relationship between protein intake and the subject's BMI percentile and waist circumference exists. Overall protein intake and protein source from diet were compared. Secondary analysis examined whether race/ethnicity influenced the outcome of BMI percentile or waist circumference when compared to the subject's protein intake and source of protein. Students from 27 elementary schools in two local school districts participated in the larger randomized, controlled KIDS study. The total subjects included in these analyzes was 1960.

During the testing period, data were collected from a different school each day. Measurements were performed on subject's height, weight and waist measurements and a 24- hour diet recall was collected. Demographic information including race/ethnicity, age, and gender were also collected at this time. Data analyzed for this research project include only baseline data from both cohorts. Descriptive statistics, frequencies, Pearson's correlation, one-way ANOVAs and stepwise multiple linear regressions were used for analysis. P values were found to be significant at  $< 0.01$  and  $< 0.05$ .

Protein adequacy was analyzed for all subjects and 94% of all subjects reported adequate protein intake while only 6% fell below adequate intake levels. Pearson's correlations were run to evaluate protein intake and subject's BMI percentile. Significance was found between subject's total protein intake ( $p < 0.01$ ),

total fat intake ( $p < 0.01$ ), and vegetable protein intake ( $p < 0.01$ ). There was no significance found in their percent protein intake and animal protein intake. Sources of protein were then correlated with subject's BMI percentile and significance was found only in soy protein intake ( $p < 0.01$ ). No significance was found in subject's meat, poultry, dairy, egg, lean meat, lean poultry or low fat/fat free dairy intake.

Waist circumference was also compared to subject's protein intake. Significance was found in percent protein intake ( $p < 0.05$ ), total fat intake ( $p < 0.01$ ), and vegetable protein intake ( $p < 0.01$ ). No significance was found in subject's total protein intake or animal protein intake. Protein sources were again compared to waist circumference and no sources were found to be significant.

A waist-height ratio was calculated to determine if subjects were either at risk or not at risk for developing weight problems later in life. All subjects were evaluated and 70% were found to be in the non-risk category and 30% were in the at risk category.

Race/ethnicity was analyzed against the different BMI categories and there was a trend found was between white–Hispanics and the Other race/ethnicity category ( $p = .074$ ). There was no significance found between any race/ethnicity and BMI categories.

Protein intake was examined by race/ethnicity. Again, white–Hispanics were found to be significant between white, non–Hispanics ( $p = .004$ ), black, non–Hispanics ( $p = .000$ ) and the Other race/ethnicity group ( $p = .021$ ). This association



showed that white–Hispanics consumed lower amounts of protein than the Other race/ethnicities included in the study.

Protein sources were analyzed by race/ethnicity and for total meat it was found that there was significance between white–Hispanics and white, non–Hispanics ( $p = .000$ ), white–Hispanics and black, non–Hispanics ( $p = .000$ ) and white–Hispanics and Other ( $p = .007$ ). For total poultry intake there was significance between white, non–Hispanics and black, non–Hispanics ( $p = .001$ ) and also white–Hispanics and black, non–Hispanics ( $p = .002$ ). For total dairy intake, there was significance between white, non–Hispanics and black, non–Hispanics ( $p = .006$ ), white, non–Hispanics and Other ( $p = .034$ ) and white–Hispanics and Other ( $p = .036$ ). There was no significance in the Egg source group. For soy intake there was significance found between white, non–Hispanics and white–Hispanics ( $p = .003$ ) and white–Hispanics and black, non–Hispanics ( $p = .011$ ) and white–Hispanics and Other ( $p = .000$ ).

Waist measurements were found to be significant between the white–Hispanics ( $p < 0.01$ ) and those in the Other ( $p < 0.01$ ) race/ethnicity category. Waist measurements were not found to be significant in white, non–Hispanics and black, non–Hispanics.

Protein intake was also compared by gender. Males averaged 67.35 g/day and females averaged 61.79 g/day, supporting research stating that males typically consume more protein in their diet than females.

A regression analysis was conducted to determine the best predictor of BMI percentile in subjects. Factors included in the model were total protein intake, total fat intake, vegetable protein, gender, white-Hispanics, Other race/ethnicity and soy protein intake. Vegetable protein, male gender, Other race/ethnicity, white- Hispanic and soy protein were found to be the best predictors of BMI percentile.

Similar regression analyses were conducted to determine the best predictor for waist circumference. Factors included in the model were total protein intake, total fat intake, vegetable protein, gender, and white-Hispanic and Other race/ethnicity. Vegetable protein, male gender and white-Hispanics were the best predictors of waist circumference.

Results from this study may be limited because of several factors. The greatest limitations may be due to the accuracy of the dietary recall. All subjects were included in the sample if they had a recall and anthropometric measurements. Subjects were not removed if they were deemed “unreliable for any reason” or if they had significantly more or less to eat the previous day. Thus, the accuracy of dietary intake may have influenced the findings.

There are few published research studies that have examined elementary aged children and their protein intake to determine whether a relationship exists between protein consumption and BMI percentile. Though correlations were weak for all results found, there was significance found. With such a large sample used, information gathered from this study could be beneficial for those wanting to further

investigate this topic to see if a randomized, controlled intervention would yield the same results.

In conclusion, total protein intake was found to be significant in a lower BMI percentile and waist circumference for subjects, specifically from vegetable or soy protein sources. Subjects who were white-Hispanic and in the Other race/ethnicity category were found to have higher BMI percentiles and waist circumferences than those in the white, non-Hispanic and black, non-Hispanic categories. These results suggest that more research in children and protein intake needs to occur with randomized, controlled, intervention trials.

## References Cited

1. American SportsData. <http://www.americansportsdata.com/obesitystats.asp>. Retrieved Feb 11, 2009.
2. Etcheverry P, Hawthorne KM, Liang LK, Abrams SA, Griffin IJ. Effect of beef and soy proteins on the absorption of non- heme iron and inorganic zinc in children. *Am Coll J of Nutr* 2006; 1: 34-40.
3. Millward DJ, Bowtell JL, Pacy P, Rennie MJ. Physical activity, protein metabolism and protein requirements. *Proceedings of the Nutrition Society* 1994; 53: 223-40.
4. Snetselaar L, Stumbo P, Chenard C, Ahrens L, Smith K, Zimmerman B. Adolescents eating diets rich in either lean beef or lean poultry and fish reduced fat and saturated fat intake and those eating beef maintained serum ferritin status. *Amer Diet Assoc.* 2004; 104: 424-428.
5. Johnstone AM, Horgan GW, Murison SD, Bremner DM, Lobley GE. Effects of a high-protein ketogenic diet on hunger, appetite, and weight loss in obese men feeding ad libitum. *Am J Clin Nutr* 2008; 87: 44-55.
6. Gunther AL, Remer T, Kroke A, Buyken AE. Early protein intake and later obesity risk: which protein sources at which time points throughout infancy and childhood are important for body mass index and body fat percentage at 7 y of age? *Am J Clin Nutr* 2007; 86: 1765-72.

7. CDC Website. <http://www.cdc.gov/nccdphp/dnpa/obesity/>. Retrieved Jan. 29, 2009.
8. Diet statistics. [www.inch-aweigh.com/dietstats.htm](http://www.inch-aweigh.com/dietstats.htm). Retrieved Jan. 29, 2009.
9. Westerterp-Plantenga MS, Lejeune MP, Nijs I, van Ooijen M, Kovacs EM. High protein intake sustains weight maintenance after body weight loss in humans. *Int J Obes Relat Metab Disord* 2004; 28: 57-64.
10. Layman DK, Clifton P, Gannon MC, Krauss RM, Nuttall FQ. Protein in optimal health: heart disease and type 2 diabetes. *Am J Clin Nutr* 2008; 87: 1571S-5S.
11. Bolton J, Abbott R, Kiely M, Alleyne M, Bell S, Stubbs L, Slevin M (1992). Comparison of three oral-sip feed supplements in patients with cancer. *Jourl of Hum Nutr and Diet* 5, 79-84.
12. Heaney RP, Layman DK. Amount and type of protein influences bone health. *Am J Clin Nutr* 2008; 87: 1567S-70S.
13. U.S. Department of Agriculture. MyPyramid: Nutrients in proposed food intake patterns. Internet:  
<http://www.cnpp.usda.gov/Publications/MyPyramid/DevelopmentMaterial/FedlRegNoticeSept2003/table5.pdf>
14. Shew SB, and Jaksic T. Thermometabolic needs of critically ill children and neonates. *Semin Pediatr Surg* 1999; 8: 131-9.

15. Bistrian BR, Blackburn GL, Scrimshaw NS, Flatt JP. Cellular immunity in semi-starved states in hospitalized adults. *Amer J Clin Nutr* 1975; 28: 1148-55.
16. McMillian– Price J, Petocz P, Atkinson F. Comparison of 4 diets of varying glycemic load on weight loss and cardiovascular risk reduction in overweight and obese young adults: a randomized controlled trial. *Arch Inter Med* 2006; 166: 1466-1775.
17. Langevin, DD, Kwiatkowski C, McKay MG, O’Sullivan Mailet J, Touger-Decker R, Smith JK, Perlman A. Evaluation of diet quality and weight status of children from low socioeconomic urban environment supports “At risk” classification. *J of Amer Diet Assoc* 2007; 107(11): 1973-1977.
18. Merchant AT, Dehghan M, Behnke-Cook D, Anand SS. Diet, physical activity, and adiposity in children in poor and rich neighborhoods: a cross-sectional comparison. *Nutr J* 2007; 6: 1-7.
19. Huynh DTT, Dibley MJ, Sibbritt DW, Hanh TM. Energy and macronutrient intakes in preschool children in urban areas of Ho Chi Minh City, Vietnam. *BMC* 2008; 1186.
20. Berkey CS, Gardner JD, Frazier AL, Colditz GA. Relation of Childhood Diet and Body Size to Menarche and Adolescent Growth in Girls. *Amer J Epidemiology*. 2000; 152(5) 446-452.

21. Yaktine, AL, Nesheim MC, James CA. Nutrient and contaminant tradeoffs: exchanging meat, poultry, or seafood for dietary protein. *Nutr Reviews* 2008; 66: 113-122.
22. FAO. Milk by- products, skim milk, buttermilk, whey. Rome: FAO; 2006.
23. Schaafsma G. The protein digestibility- corrected amino acid score (PDCAAS) for describing protein quality in foods and food ingredients. *J AOAC Int.* 2005; 88:988-94.
24. Fulgoni VL. Current protein intake in America: analysis of the National Health and Nutrition Examination Survey, 2003-2004. *Am J Clin Nutr* 2008; 87: 1554S-7S.
25. Pilvi TK, Korpela R, Huttunen M, Vapaatalo H, Mervaala EM. High- calcium diet with whey protein attenuates body weight gain in high fat fed C57B1/6J mice. *Br J Nutr* 2007 Nov; 98 (5): 900-7. Epub 2007 Aug 13.
26. Royle PJ, McIntosh GH, Clifton PM. Whey protein isolate and glycomacropeptide decrease weight gain and alter body composition in male Wistar rats. *Br J Nutr.* 2008 Jul; 100(1): 88-93. Epub 2007.
27. Frestedt JL, Zenk JL, Kuskowski MA, Ward LS, Bastian ED. A whey protein supplement increases fat loss and spares lean muscle in obese subjects: a randomized human clinical study. *Nutr metab (Lond)* 2008 Mar 27; 5:8.

28. Harvey-Anderson G, Tecimer SN, Shah D, Zafar TA. Protein source, quantity and time of consumption determine the effect of proteins on short-term food intake in young men. *J Nutr* 134: 3100-3015, 2004.
29. Millward DJ. The nutritional value of plant-based diets in relation to human amino acid and protein requirements. *Proc Nutr Soc.* 1999; 58:249-60.
30. Endres, J, Barter S, Theodora P, Welch P. Soy-enhanced lunch acceptance by preschoolers. *J Amer Diet Assoc* 2003; 103: 346-351.
31. Weghuber D, Widhalm K. Effect of 3-month treatment of children and adolescents with familial and polygenic hypercholesterolaemia with a soya-substituted diet. *British Journal of Nutrition* 2008; 99: 281-286
32. Ogden, CL, Carroll MD, Flegal KM. High Body Mass Index for Age Among U Children and Adolescents, 2003-2006. *JAMA.* 2008; 299(20): 2401-2405.
33. Eisenstein J, Roberts SB, Dalial G, Saltzman E. High Protein Weight Loss Diets: Are they safe and Do They Work? Are Review of the Experimental and Epidemiological Data. *NutrReview.* 2002; 60 (7): 189-200.
34. VanVaught, AJ, Heitmann BL, Nieuwenhuizen AG, Veldhorst MA, Brummer RJ, Westererp-Plartenga, MS. Association between Dietary Protein and Change in Body Composition among Children. *Clin Nutr.* 2009, Jun 11.



35. Yamashita T, Sasahara T, Pomeroy SE, Collier G, Nestel PJ. Arterial compliance, blood pressure, plasma leptin, and plasma lipids in women are improved with weight reduction equally with a meat based-diet and a plant-based diet. *Metabolism*. 1998;47:1308–1314.
36. Deibert P, Konig D, Schmidt-Trucksäess A, Zaenker KS, Frey I, Landmann U, Berg A. Weight loss without losing muscle mass in pre-obese and obese subjects induced by high-soy-protein diet. *Int J Obes Relat Disord*. 2004;28:1349–1352.
37. Bosello O, Cominacini L, Zocca I, Garbin U, Compri R, Davoli A, Brunetti L. Short- and long-term effects of hypocaloric diets containing proteins of different sources on plasma lipids and apoproteins of obese subjects. *Ann Nutr Metab*. 1998;32:206–214.
38. Westerterp-Plantenga MS, Rolland V, Wilso SA, Westerterp KR. Satiety related to 24 hour diet induced thermogenesis during high-protein/carbohydrate vs. high fat diets measured in respiratory chamber. *Eur J Clin Nutr* 1999; 53: 495 – 502.
39. Trichopoulou A, Psaltopoulou T, Orfanos P, Hsieh CC, Trichopoulos D. Low-carbohydrate-high-protein diet and long-term survival in a general population cohort. *Euro J Clin Nutr* 2007; 61: 575-581.

40. Johnstone AM, Horgan GW, Murison SD, Bremner DM, Lobley GE. Effects of a high-protein ketogenic diet on hunger, appetite, and weight loss in obese men feeding ad libitum. *Am J Clin Nutr* 2008; 87: 44-55.
41. Bernstein A. Are high-protein diets safe for kidney function? *J Amer Dietetic Assoc* 2007; 1722.
42. Baylor College of Medicine. Daily values versus nutritional recommendations for children. [www.kidsnutrition.org/consumer/archives/percentDV.htm](http://www.kidsnutrition.org/consumer/archives/percentDV.htm). Retrieved Jan. 8, 2009
43. Shawnee Mission School District Gender and Race Breakdown. <http://www.localschooldirectory.com/district-schools/D0512/Shawnee-Mission-Public-School-District/KS>. Retrieved Feb 10, 2009.
44. Lohman TG, Roche AF, Mortorell R. Standardization Reference Manuel. Human Kinetics Books: Champaign, Illinois. 1998.
45. Kellow, Juliette, BSc RD. The Simplest Way to Monitor Children's Weight...Ever! [www.weightlossresources.co.uk/children/monitor\\_childrens\\_weight.htm](http://www.weightlossresources.co.uk/children/monitor_childrens_weight.htm) Retrieved Mar 16, 2009.
46. Protein sources. [www.americanheart.org/presenter.jhtml](http://www.americanheart.org/presenter.jhtml). Retrieved Feb 11, 2009.

47. Food Pyramid Chart and food servings.  
[www.MyPyramid.gov/pyramid/meat\\_amount.aspx#](http://www.MyPyramid.gov/pyramid/meat_amount.aspx#) Retrieved June 27, 2009.
48. Motulsky H. Intuitive Biostatistics: choosing a statistical test. Oxyford University Press, 1995. <http://www.graphpad.com/www/Book/Choose.htm>  
Retrieved Feb, 11, 2009.
49. Lancotot JQ, Klesges RC, Stockton MB, Klesges LM. Prevalence and characteristics of energy underreporting in African-American girls. Obesity (Silver Spring). 2008 Jun;16(6):1407-12. Epub 2008 Apr 3.
50. Singh R, Martin BR, Hickey Y, Teegarden D, Campbell WW, Craig BA, Schoeller DA, Kerr DA, Weaver CM. Comparison of self-reported, measured, metabolizable energy intake with total energy expenditure in overweightteens. Am J Clin Nutr. 2009 Jun;89(6):1744-50.
51. Heitmann, B.L. and L Lissner. Dietary Underreporting by Obese Individuals- is it specific or non-specific? *BMJ*. 1995; 311(7011): 986-989.
52. Lindroos AK, Lissner L, Sjöström L. Does degree of obesity influence the validity of reported energy and protein intake? Results from the SOS Dietary Questionnaire. Swedish Obese Subjects. Eur J Clin Nutr. 1999May;53(5):375-8.
53. Subar AF, Kipnis V, Troiano RP, Midthune D, Schoeller DA, Bingham S, Sharbaugh CO, Trabulsi J, Runswick S, Ballard-Barbash R, Sunshine J, Schatzkin A. Using intake biomarkers to evaluate the extent of dietary

- misreporting in a large sample of adults: the OPEN study. *Am J Epidemiol*. 2003 Jul 1;158(1):1-13.
54. VanVaught, AJ, Heitmann BL, Nieuwenhuizen AG, Veldhorst MA, Brummer RJ, Westererp–Plartenga. Association between Dietary Protein and Change in Body Composition among Children. *Clin Nutr*. 2009, Jun 11.
55. Xie B, Gilliland FD, Li Y, Rockett H. Effects of Ethnicity, Family Income and Education on Dietary Intake among Adolescents. *Preventative Med*; 2003 (36) : 30-40
56. Konig D, P Deibert, I Frey, U Landmann, A Berg. Effect of Meal Replacement on Metabolic Risk Factors in Overweight and Obese Subjects. *Amer Nutr Met*. 2008; 52 (1) 74-78.
57. Wang, YF, WS Yancy, D Yu, C Champagne, LJ Appel, PH Lin. The Relationship between Dietary Protein Intake and Blood Pressure: Results from the PREMIER study. *Journl of Hum HTN*: 2008 (22) 745-754.
58. Storey KE, Forbes LE, Fraser SN, Spence JC, Plotnikoff RC, Raine KD, Hanning RM, McCargar LJ. Diet Quality in Nutrition and Physical Activity among Adolescents: the WEBSPAN project. *Pub Health Nut*. 2009; (23) 1-9.
59. Mazur RE, Marquis GS, Jensen HH. Diet and Food Insufficiency among Hispanic youths: acculturation and socioeconomic factors in the third National Health and Nutrition Examination Survey. *J Amer Diet Assoc*; 78: 1120-7.

60. Farnsworth E, Luscombe ND, Noakes M, Wittert G, Argyiou E, Clifton PM. Effect of a high-protein, energy-restricted diet on body composition, glycemic control, and lipid concentrations in overweight and obese hyperinsulinemic men and women. *Am J Clin Nutr* 2003;78:31-9.
61. Vander Wal JS, Gupta A, Khosla P, Dhurandbar NV. Egg Breakfast Enhances Weight Loss. *Int J Obes*. 2008 Oct; 32(10): 1545-51.
62. Wang YF, Yancy WS Jr., Yu D, Champagne C, Appel LJ, Lin PH. The relationship between dietary protein intake and blood pressure. *J Hum Hypertens*. 2008 Nov, 22(11): 745-754.
63. Zemel MB, Thompson W, Milstead A, Morris K, Campbell P. Calcium and dairy acceleration of weight and fat loss during energy restriction in obese adults. *Obes Res*. 2004 Apr; 12(4): 582-590.
64. Carrera PM, Xiang G, Tucker KL. A Study of Dietary Patterns in the Mexican-American Population and their Association with Obesity. *J Amer Diet Assoc*; 2007 (107) 1735-1742.
65. Arcan C, MY Kubik, JH Fulkerson, M Storey. Sociodemographic differences in selected eating practices Among Alternative High School Students. *J Amer Diet Assoc*; 2009 (109) 823-9.

66. Livingstone MBE, Robson PJ, Wallace JMW. Issues in Dietary Intake Assessment of Children and Adolescents. *Brit Journl Nutr.* 2004; 92: S213-S222.
67. Fisher JO, Johnson RK, Lindquist C, Birch LL, Goran MI. Influence of Body Composition on the Accuracy of Reported Energy Intake in Children. *Obes Res.* 2000; 8(8): 597-603.

Appendix A

Approved Informed Consent Form

**University of Kansas Medical Center  
Snack Nutrition Program**

Dear Parents:

We are inviting all children in grades 3-5 to take part in a snack program at our school. If you decide to let your child participate, then your child may receive healthy snacks each school day if your school is chosen. Half of the schools participating in the program will receive the snacks and the other half of the schools will not receive the snacks. Dietitians from the University of Kansas Medical Center will direct the program.

The purpose of the program is to find out if eating 2 servings of dairy foods every school day will affect children's blood pressure and growth rate.

At the start of the school year, we will measure your child's height, weight, arm circumference, waist circumference, and blood pressure. To find out how active your child is, we will ask some questions about physical activity. We will also ask about the foods your child eats. After the testing is done, if your child is at the school that receives snacks, then he/she will be given healthy snacks each school day for the entire school year. At the middle and end of the year, we will do the same tests again.

If you want your child to be in the program, you must fill out the attached consent form. If you do not wish your child to be part of the program, simply sign the note below and return the form to the school. If you have any questions, we will be at your child's school during the back to school night or you may call us at (913) 588-5357.

We look forward to working with your child. We hope that everyone can participate.

Sincerely,

Debra K. Sullivan

-----  
Your child's grade level (circle one):            3    4    5

\_\_\_\_\_ YES, I agree to have my child participate.

\_\_\_\_\_ NO, I do not want my child to participate in the snack nutrition program.

Parent Name: \_\_\_\_\_

Child's Name: \_\_\_\_\_

Address: \_\_\_\_\_

Telephone Number: \_\_\_\_\_



**University of Kansas Medical Center**  
**(Centro Médico de la Universidad de Kansas)**  
**Programa de meriendas nutritivas**

Estimados padres:

Estamos invitando a todos los niños de 3-5 grado a participar en un programa de meriendas en nuestra escuela. Si usted decide permitirle participar a su hijo(a), es posible que él (ella) reciba meriendas saludables cada día escolar. Una parte de las escuelas en el programa recibirán meriendas, y la otra parte no las recibirán. El programa será dirigido por especialistas en dietética del Centro Médico de la Universidad de Kansas.

El propósito del programa es descubrir si el consume de 2 porciones de alimentos lácteos cada día escolar afecta la presión arterial y el crecimiento de su hijo(a).

Al comienzo del año escolar, tomaremos las medidas de estatura, peso, circunferencia del brazo, cintura, y además la presión arterial de su hijo(a). Para averiguar el nivel de actividad que tiene su hijo(a), nosotros haremos algunas preguntas sobre su actividad física. También haremos preguntas sobre los alimentos que come su hijo(a). Después de terminar todas las pruebas, si su hijo(a) es estudiante en una de las escuelas que recibe las meriendas, su hijo(a) recibirá meriendas saludables cada día escolar durante todo el año académico. Al final y a los mediados del año, volveremos a las escuelas para hacer las mismas pruebas.

Si usted desea que su hijo(a) sea parte del programa, debe llenar el formulario de consentimiento que hemos adjuntado. Si no desea que su hijo(a) participe en el programa, simplemente firme la nota de abajo y devuelva el formulario a la escuela. Si tiene preguntas, estaremos en la escuela de su hijo(a) en la noche de regreso a clases, o puede llamarnos al (913) 588-5357.

Tenemos grandes deseos de trabajar con su hijo(a). Esperamos que todos puedan participar.

Atentamente,

Debra K. Sullivan

-----  
Grado escolar de su hijo(a) (marquee uno con un círculo):            3    4    5

\_\_\_\_\_ Sí, estoy de acuerdo en que mi hijo(a) participe.

\_\_\_\_\_ NO, no quiero que mi hijo participe en el programa de bocado nutritivo.

Nombre del padre o de la madre: \_\_\_\_\_

Nombre del hijo(a): \_\_\_\_\_

## **Dairy Foods and Blood Pressure in Multi-Ethnic Children**

### **INTRODUCTION**

As a parent with a third, fourth, or fifth grade student in the Kansas City, Olathe, or Shawnee Mission Kansas School District, your child is being invited to participate in a study to determine if consuming 2 servings of dairy foods per day at school will affect his/her blood pressure. This study will be performed at your child's school by investigators from the University of Kansas Medical Center, Department of Dietetics and Nutrition.

### **PURPOSE**

The primary objective for the study is to increase dietary intake of calcium by grade school children and evaluate the effect of the intervention on blood pressure. The secondary purpose will be to determine if the dairy snacks have any effect on your child's growth.

### **PROCEDURE**

Your child's participation in this study will involve drinking or eating 2 servings of dairy foods as snacks or continuing to follow the current practice of receiving no snacks at school. Whether he/she receives the dairy or no snacks will depend on which school he/she attends. Half the schools will be randomly chosen to receive the dairy foods and the other schools will receive no snacks. If your child is at a school that receives the dairy snacks, he/she will need to consume the snack for one school year. If your child is at a school that receives no snacks, there will be no change at his/her school.

At the beginning, middle, and end of the year, he/she will be measured for height, weight, waist circumference, arm circumference, triceps skinfold, and blood pressure/heart rate. The blood pressure cuff may be uncomfortable and your child may say at any point that he/she wants to stop the testing. To see what your child is eating, you will help your child record what he/she eats and then he/she will use that record to tell the investigators everything that he/she ate for one day. You and your child will do this for one day at the beginning, middle, and end of the school year. Your child will also fill out two short questionnaires at the beginning and end of the school year. One questionnaire will ask him/her which foods he/she eats more often, which food he/she would rather eat, which foods are healthier, etc. The other questionnaire will ask him/her how much physical activity he/she does on most days. You will also be asked to fill out a short Medical History form for your child and yourself at the beginning of the study. This is to make sure there are no medical conditions or medications that may interfere with the study or health of your child.

To see if the snacks have any long term effect, your child will have his/her blood pressure/heart rate taken and will complete a record of his/her diet for 3 days in the fall and spring of the following school year. Administering the snacks will take approximately 10 minutes from your child's school academic day. Snack consumption will occur during class time in order to minimize disruption of academic time. The physical measurement will

require approximately twenty minutes of time at baseline, midway, and conclusion of the study. Recording what your child eats will take approximately 20 minutes for each day. The time required to conduct the measurements of this study will be incorporated into your child's curriculum (science) to minimize disruption of academic learning. All measures will occur at your child's school.

### **RISKS**

There are no risks to your child in this study. He/she may feel some abdominal discomfort if he/she is lactose intolerant and in the group receiving dairy products. He/she does not have to eat or drink the milk product(s) if it causes discomfort. Lactose free milk or other tolerable dairy foods will be provided. The physical measurements will not hurt your child, but he/she may feel a small pinch when his/her triceps skinfold is measured. He/she may feel pressure from the blood pressure cuff. He/she may stop the test at any time. This study may decrease the time your child has for academic lessons, but the time will be minimized and incorporated into learning activities when possible.

### **BENEFITS**

Your child may receive a nutritious snack for free for one school year. Foods high in vitamins and minerals are known to have positive health benefits. You will receive a printout with your child's results from the testing.

### **PAYMENT TO SUBJECTS**

Neither you nor your child will receive payment for participation in this study.

### **COSTS**

There are no costs involved in participating in this study.

### **ALTERNATIVES**

Your child may continue to eat or drink the snacks even if he/she no longer chooses to participate in the study or refuses to complete certain parts of the study.

### **INSTITUTIONAL DISCLAIMER STATEMENT**

If you believe that you have been injured as a result of participating in research at Kansas University Medical Center (KUMC), you should contact the Director, Human Research Protection Program, Mail Stop #1032, University of Kansas Medical Center, 3901 Rainbow Blvd., Kansas City, KS 66160. Compensation to persons who are injured as a result of participating in research at KUMC may be available, under certain conditions, as determined by state law or the Kansas Tort Claims Act.

### **CONFIDENTIALITY AND PRIVACY AUTHORIZATION**

Study records that identify your child will be kept confidential as required by law. Researchers cannot guarantee absolute confidentiality; however, efforts will be made to keep your child's personal information confidential. If the results of this study are published or presented in public, information that identifies your child will be removed.

The privacy of your child's health information is protected by a federal law known as the Health Insurance Portability and Accountability Act (HIPPA). By signing this consent form, you are giving permission for KUMC to use and share your child's health information for purposes of this research study. If you decide not to sign the form, your child cannot be in the study.

To do this research, the research team needs to collect health information that identifies your child. Your child may be identified by information such as name, date of birth, or other identifiers. The research team will collect information from study activities described in the Procedures section of this form. Your child's study health information will be reviewed by the principal investigator Debra Sullivan, Ph.D., R.D., members of her research team, the Research Institute, and the Human Subjects Committee at KUMC. These offices review research studies to protect study participants like your child.

By signing this form, you are giving Dr. Sullivan and her research team permission to share information from this study with the National Institutes of Health (the sponsor of the study) and federal agencies that oversee research.

Some of the persons or groups who receive your child's study information, including the sponsor, may not be required by law to protect it. Once your child's information has been shared outside of KUMC, it may be disclosed by others and no longer protected by the federal privacy laws or this authorization.

The permission that you give us today to use your child's study information will not expire unless you cancel it. In other words, you are giving permission for us to use your child's study information at any time in the future.

### **QUESTIONS**

Before you sign this form, Dr. Sullivan or her associates should answer your question(s) to your satisfaction. If you have any more questions, concerns, or complaints after signing this form, you may contact Dr. Debra Sullivan at (913) 588-5357 or Dr. Cheryl Gibson at (913) 588-7202. If you have any questions about your child's rights as a research subject, you may call (913) 588-1240 or write the Human Subjects Committee, Mail Stop #1032, University of Kansas Medical Center, 3901 Rainbow Blvd., Kansas City, KS 66160.

### **SUBJECT RIGHTS AND WITHDRAWAL FROM THE STUDY**

Your child's participation in this study is voluntary. The choice not to participate or to quit at any time can be made without penalty or loss of benefits. These decisions will have no effect on your child's future medical care. The study may be stopped for any reason without your consent by the investigator conducting the study or by the sponsor the National Institutes of Health. Your child's participation can be discontinued by the investigator or the sponsor if it is felt to be in your child's best interest or if he/she does not follow the study requirements.

You have the right to change your mind about allowing the research team to have access to your child's study information. To cancel your permission, you must send a written request to Dr. Sullivan at the University of Kansas Medical Center, Department of Dietetics and Nutrition, 3901 Rainbow Boulevard, Mail Stop 4013, Kansas City, KS 66160.

If you cancel permission to use your child's study information, your child will be withdrawn from the study. The investigator may continue to use your child's study information that was gathered prior to your cancellation, however, no additional information will be collected.

### **CONSENT**

Dr. Sullivan or her associates have given you information about this research study. They have explained what will be done to your child, what your child will have to do, how it will be done, and how long it will take. They also explained any inconvenience, discomfort or risks that your child may experience during this study.

You freely and voluntarily consent to allow your child to participate in this research study. You have read the information in this form and have had an opportunity to ask questions and have them answered. **You will be given a signed copy of this consent form to keep for your records.**

---

Type/Print Parent or Legal Guardian Name

---

Signature of Parent or Legal Guardian

---

Date

### **Assent for Minor Child**

Your parents have given you permission to be part of a study about how eating snacks at school affects your blood pressure and growth. If you want to be part of the study, you will need to eat the snacks given to you at school. You will receive the snacks for 6 months. Before the research study starts at school you will have your blood pressure/heart rate, height, weight, waist and arm size and body fat measured. Your body fat will be measured by pinching the back of your upper arm. After the research study starts, you will have your blood pressure, weight, height, waist and arm size, and body fat measured after 3 months of the study and again at the end. You will also have to tell us everything you ate or drank for one whole day and answer some questions about foods you regularly eat at the beginning, middle, and end of the study. If you sign your name to the line it means that you want to be part of the research. You know that you do not have to do it and that you can stop being in the research at any time you want even if you signed the paper. If you want to stop all you need to do is tell your parents or call the investigator at 588-5357.

Name of Child: \_\_\_\_\_

Signature of Child: \_\_\_\_\_

Date: \_\_\_\_\_

Age of Child: \_\_\_\_\_

## Appendix B

### Kids Anthropometric Data Form

## KUMC KIDS Data Collection Form

<b>Administrative Use Only - Affix Label Here</b>	
Subject's Name: _____	Time _____
Subject ID: _____	Date/Period: ____/____/____ (Baseline, 3 months, 6 months)      ____ : ____ am / pm (circle one)
School/School ID: _____ / _____	Teacher/Grade: _____ / _____ grade

Age: \_\_\_\_ years

Date of Birth (mo/day/year): \_\_\_\_/\_\_\_\_/\_\_\_\_

Grade (circle one):    3rd    4th    5th

Gender (circle one):    Boy    Girl

**What race do you consider yourself to be?**

**Select all that apply:**

- ☐ White  
☐ Black  
☐ Hispanic  
☐ Asian/Pacific Islander  
☐ American Indian/Alaskan Native  
☐ Other (please explain) \_\_\_\_\_

	Measurements	Unit	Comment (circle one if needed)	Initials										
<b>Height</b>	1) _____ . ____ 2) _____ . ____ 3) _____ . ____	Cm	1. Refused 2. Unable to stand without support 3. Difficult to assess (e.g. hair) 4. Other: _____	____										
<b>Weight</b>	1) _____ . ____ 2) _____ . ____ 3) _____ . ____	Kg	1. Refused 2. Unable to stand without support 3. Shoes 4. Other: _____	____										
<b>Waist Circumference</b>	1) _____ . ____ 2) _____ . ____ 3) _____ . ____	Cm	1. Refused completely 2. Excess clothing (i.e. sweatshirt) 3. Over Shirt: _____	____										
<b>Mid-Arm Circumference</b>	1) _____ . ____ right arm	Cm	<i>Measure for Blood Pressure Cuff Size</i>	____										
<b>Blood Pressure/ Heart Rate</b> (discard 1st measurement)	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; text-align: center;">Blood Pressure</td> <td style="width: 50%; text-align: center;">Heart Rate</td> </tr> <tr> <td>1) _____ / ____</td> <td>_____</td> </tr> <tr> <td>2) _____ / ____</td> <td>_____</td> </tr> <tr> <td>3) _____ / ____</td> <td>_____</td> </tr> <tr> <td>4) _____ / ____</td> <td>_____</td> </tr> </table>	Blood Pressure	Heart Rate	1) _____ / ____	_____	2) _____ / ____	_____	3) _____ / ____	_____	4) _____ / ____	_____	mmHg	1. Refused 2. Did not rest long enough 3. Will not stop fidgeting 4. Other: _____	____
Blood Pressure	Heart Rate													
1) _____ / ____	_____													
2) _____ / ____	_____													
3) _____ / ____	_____													
4) _____ / ____	_____													
<b>PAQ Complete</b>	____	<b>DQ complete</b>	____	<b>Diet Recall Complete</b>										
			____	____										

Version 4 - 07/20/2008



## Appendix C

### 24 – Hour Recall Form

# KUMC Kids Study

**Subject Name/ID #\_\_\_\_\_ Date of Intake: \_\_\_\_\_**

**Testing Period: Baseline / 3 months / 6 months**

**Recall #:**    1      2      3

**Weekday / Weekend**

**Interviewer:** \_\_\_\_\_

**Entered**\_\_\_\_\_ **Checked**

[illegible]

Time/Place Amount	Meal	Food/Beverage Description	

Was intake: Typical? Considerably more than usual? Considerably less than usual?  
Why?

Was recall: Reliable? Unable to recall 1 or more meals? Unreliable for other reasons?  
Why?

Vitamin/Mineral/Supplement Use/Dosage?

What time did you go to bed last night?

What time did you wake up this morning?

Is this your normal time to go to bed and time to get up in the morning? Please explain if not normal?